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The WELDING Journal

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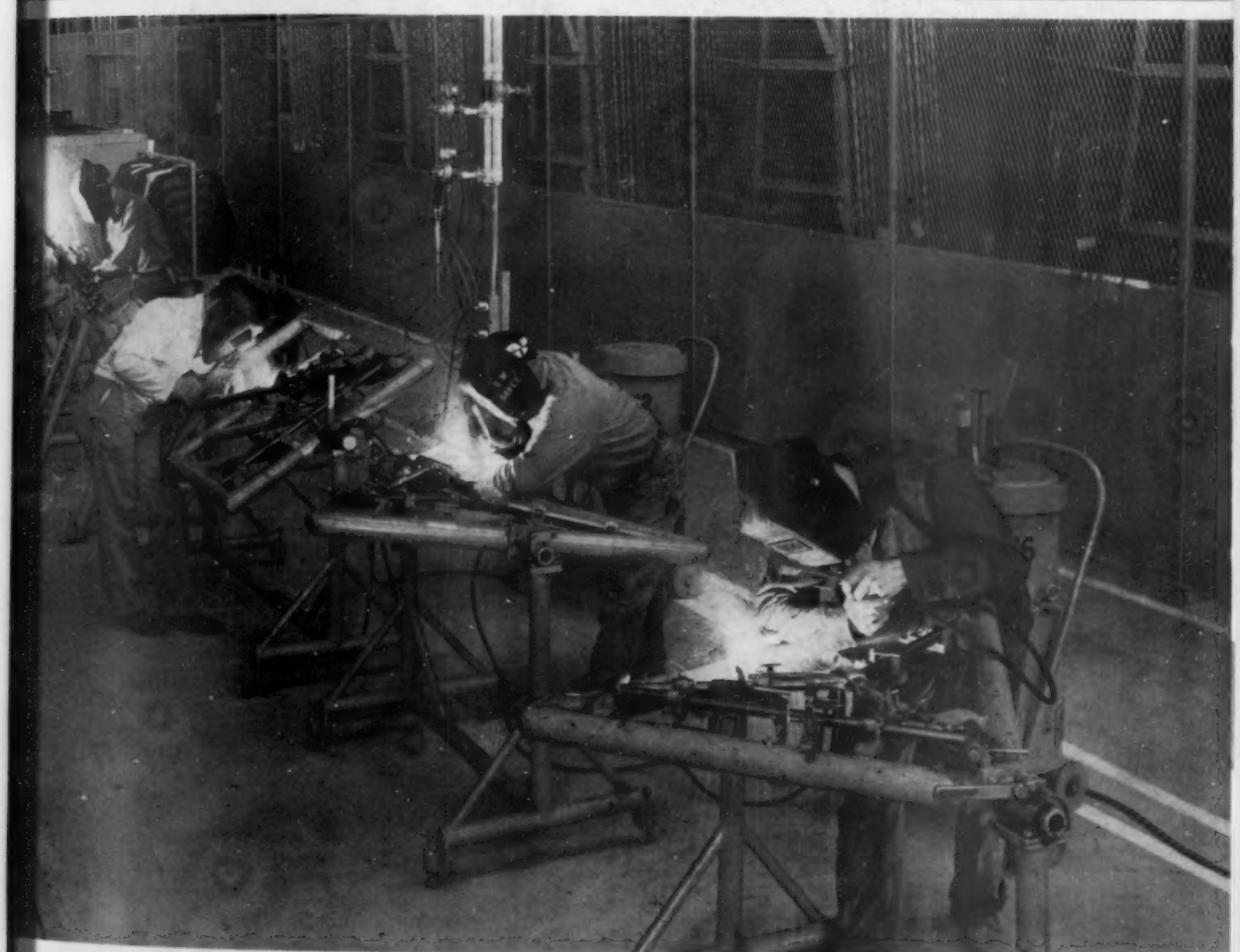

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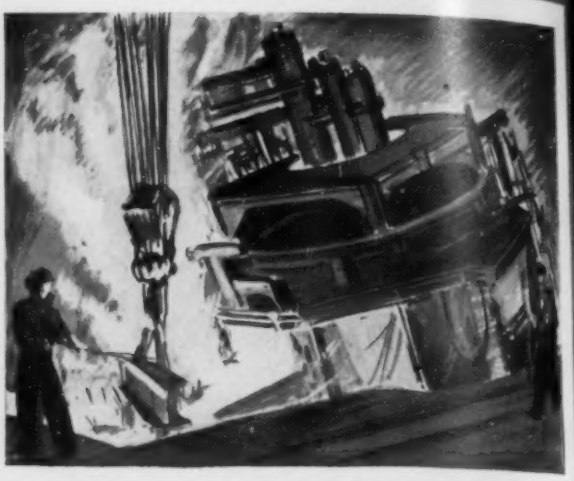

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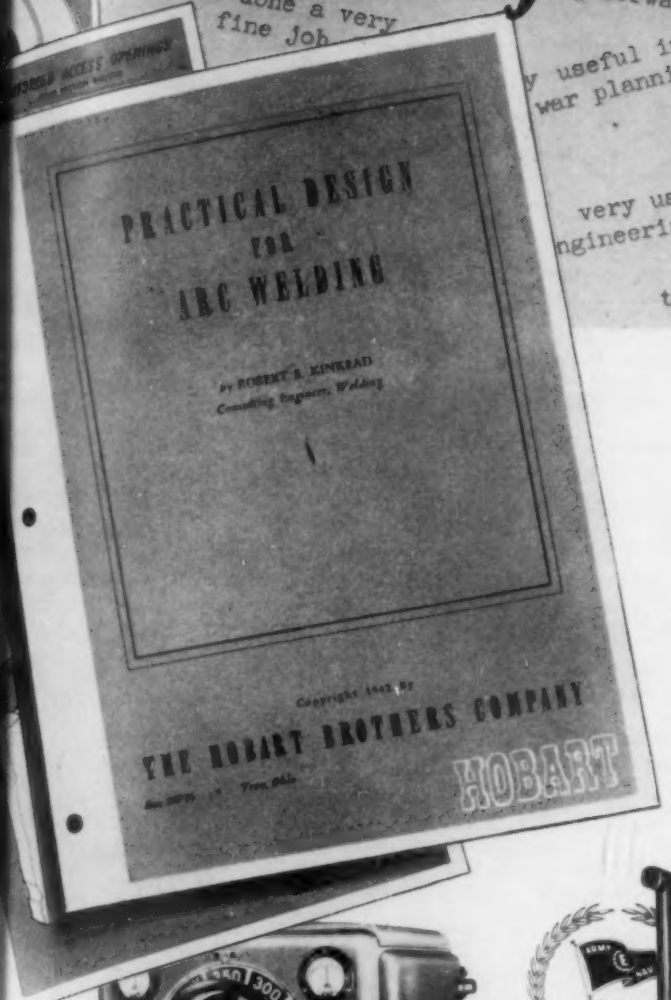

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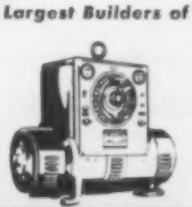

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W. SPRARAGEN, Editor

October 1943

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COVER

Arc Welding Aircraft Parts.—

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CONTENTS

TECHNICAL PAPERS, ITEMS AND REPORTS

The Application of Flash Welding in Airplane Construction, by C. B. Smith 769
Machine Cutting for Assembly Line Fabrication, by C. O. Adams ... 776
Transition from Riveted to Welded Construction of Light Combat Tanks, by William Osha and John W. Sheffer 780
Modern Welding Methods for Copper and Copper Alloys, by J. J. Vreeland 784
Welding as It Applies to Railroads, by Robert Moran 793
Reclamation by Hard Facing, by F. G. Jones 797
Locomotive Parts Fabrication and Welding of Bronze Bearing Surfaces, by J. W. Kenefic 799
Welding Operator Training, by Arthur N. Kugler 806
Why the Weld Recorder, by J. R. Fetcher and J. Van Den Beemt ... 815
Electric Resistance-Welded Steel Tubing—Its Quality Control and Application, by R. D. Malm 818
Applicable Methods of Inspection for Pressure Vessels and Piping, by Wm. D. Halsey 821
The Welded Locomotive Boiler, by E. G. Young 823
Current Welding Literature 827

SOCIETY AND RELATED ACTIVITIES

Our President—David Arnott 830
Our First Vice-President—Isaac Harter 830
Our Second Vice-President—A. C. Weigel 830
Our Directors-At-Large 834
Index to Advertisers 834
Our District Vice-Presidents 838
The Adams Lecture 842
Obituary—Leon S. Moisseiff 845
Obituary—Charles F. Williams 846
Obituary—Albion James Wadhams 848
"E" Flag 848
New Welding House Organ 850
Safety Congress 850
Kewanee Boilers Win White Star on "E" Production Flag 850
Aeronca Aircraft Corporation Win Army-Navy "E" 850
Second Star in "E" Flag for P & H ... 850
Metal & Thermit Appointments 852
Jones Appointed Sales Manager 852
Lincoln Consulting Engineer 854
Office of War Information, U. S. Maritime Commission 854
Stored Energy Welders 856
Using Today's Solders 856
Greenport War Vessels 856
Welding Plowshares 856
Stainless Steel Electrodes 856
Welder's Vest Pocket Guide 858
Light Bench-Type Electric Spot Welders 858
Blind Date with a Convoy 858
Engineers See Launching of Ship ... 858
New Coolant Cooler Bulletin 858
New Products 860
1940–42 Lincoln Foundation Studies in Arc Welding Now Available in Book Form 864
Office of War Information, War Production Board 864
List of New Members 866
Members Reclassified 870
Sustaining Member 872
Section Activities 872
Employment Service Bulletin 874
Industrial Electronics Conference ... 874
Section—Chairmen, Secretaries, and Regular Meeting Dates 876

WELDING RESEARCH SUPPLEMENT

Weld-Bead Hardness Tests on Some Carbon, Nickel and Nickel-Chromium War Department Steels, by Oscar E. Harder and C. B. Voldrich 441-s
Reviews of Recent Foreign Welding Literature 450-s
Spot Welding of S.A.E. 1020, 1035 and 1045 Steels in the 0.040 In. Thickness, by W. F. Hess and D. C. Herrschaft 451-s
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The Journal of
The American Welding Society
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The Application of Flash Welding in Airplane Construction*

By C. B. Smith†

ABOUT five years ago, the Douglas Company purchased its first flash weld machine. This investment was not made without misgivings on the part of some who questioned the wisdom of the outlay of such a large amount of cash. The machine was not purchased blindly, however, because the use of flash welding equipment was daily becoming more popular in the automobile industry, and, of course, the backers of the flash weld process at Douglas had several applications in mind for it. The job which had been particularly troublesome was the fabrication of a heavy boiler flange. The total welding area was in excess of 2 sq. in.; consequently, a 450-kva. machine was purchased.

Within a few months after the first machine had been delivered and put to work, it had saved its price in material and machine shop time. From then on, the use of flash welding in the aircraft industry was assured.

In order to eliminate confusion, it seems advisable at this point to describe the process as we are using it for the welding of aircraft parts. "Flash welding" is the formation of a butt-type weld by means of an automatic flash welding machine. The machine is a precision device of rugged construction. In its bare essentials it consists of one stationary platen and one movable platen mounted on accurate ways. The platens, in the electrical sense, are insulated from each other. Some sort of automatic drive unit is incorporated to control the motion of the movable platen toward the stationary one. A set of current-carrying "dies" is mounted on each platen and connected to a transformer so that the die sets will be opposite in polarity. Each of the two parts to be welded is clamped in its die, set in such a manner that it protrudes toward the other part in accurate alignment. Suitable back stops or locating fixtures, if required, may also be mounted on the platens. An alternating current of high intensity but low voltage is applied, and one part is moved toward the other. When the parts come into contact, the contact areas are flashed away by the intense current. The motion of one part toward the other is so regulated that steady vigorous flashing is maintained, thus providing both a heating and a cleansing action. Flashing is caused to cease by suddenly forging the heated parts together and turning off the current before excessive heating during this "upset" period can occur and destroy or "burn out" the weld.

The machine is automatic in that once set up it repeats each cycle in nearly an identical manner. Control adjustments are provided for current magnitude, travel time, distance traveled during the flashing period, platen speed at any point in the cycle and the time at which the current is turned off with relation to the upset action. The methods used by different equipment manufacturers for making these adjustments vary somewhat, as do other details of machine construction; consequently, flash welding applications have been strongly influenced by equipment design.

Since the first machine was purchased to do a specific job, only enough research was done, prior to placing the machine on production, to develop machine settings that would consistently produce satisfactory welds for this application. As each new application appeared, similar cut-and-try tests were run. As a result of these tests, it became apparent that one size machine was in-

FLASH WELD OPERATION SHEET
Form 37-101 (Rev. 5-43)

DRAWING NUMBER
LATEST DWG. CHANGE
PLANNING NUMBER
APPROVAL
DATE APPROVED

MATERIAL DESCRIPTION:

AREA OF CROSS SECTION AT WELD (SQ. IN.)

MACHINE TO BE USED

TOOLING TO BE USED

TOTAL LOAD PER WELD
TEMPLATE OR CAM NUMBER
CURRENT SETTING
SPEED SETTING

ADDITIONAL MACHINE SETTINGS - TO BE MADE IN THE ORDER GIVEN

1. 6.
2. 7.
3. 8.
4. 9.
5. 10.

PRODUCTION RECORD

FILL IN THE DATA REQUIRED BELOW. MAKE A TEST AS FOLLOWS:

MINIMUM ACCEPTABLE REQUIREMENTS ARE:

RECORD "W" AFTER FAILING LOAD FOR FAILURE IN WELD - "P" FOR FAILURE IN PARENT MATERIAL.

ORDER NO.	SERIAL NO.	NO. OF PARTS	DATE	OPERATOR	SET UP CHECK	PRODUCTION TEST	

Fig. 1—The "Setup" Card

* To be presented at the Annual Meeting, A.W.S., Chicago, Ill., Oct. 18 to 21, 1943.

† Process Engineering Dept., Douglas Aircraft Co., Inc., Long Beach, Calif.

adequate to cover the entire range of aircraft applications, and that definite engineering design data must be developed. An additional machine of 50-kva. rating was purchased and a research program was established.

Two problems were in immediate need of solution:

1. The development of a flash welding technique which would consistently produce reliable results.
2. The determination of the strength values of flash welds made using this technique.

The investigators discovered that a comparatively large number of setting combinations would produce what appeared to be sound welds. With so many welding variables, some arbitrary selection of constants seemed necessary if any progress was to be made. This selection of constants was based on recommendations received from one of the welding machine manufacturers for the flash welding of mild steel of rectangular cross section. Inasmuch as aircraft applications are largely alloy steel tubing, use was made of the recommendations by converting our tube section to its equivalent rectangular section by simply considering that the same thickness applied for each, while the area of cross section of the tube, divided by its thickness, would give the equivalent width dimension. According to the recommendation, width and thickness governed the total loss, of which about one-fifth was upset travel. The final or closed position of the clamping dies was based on thickness; the time used for flashing was based on area of cross section; the current was to be set as needed. Many welds were made using settings based on these recommendations, and the results were very gratifying.

It was soon found that both the welders in use were too large in capacity for many small assemblies where flash welding seemed to be the most logical welding process. As a result, a 10-kva. machine was purchased. These three machines, the 450, the 50 and the 10, seemed to provide adequate coverage of the welding range, although there was very little overlapping. In subsequent equipment purchases, a similar pattern of machine sizes has been maintained. Extra equipment such as auxiliary autotransformers and a wide selection of cam shapes has increased the overlapping of machine ranges, and has led to more consistent welding and more satisfactory performance. Where production warrants it, the spread between machine sizes might even be reduced.

Samples of alloy steels were welded at proved settings and submitted for fatigue and tensile tests. In nearly every case tested, the parts failed at considerable distance from the weld, and those few which failed in the weld broke at values comparable to an unwelded control specimen. These tests have resulted in the acceptance of unheat-treated flash welds as having a strength equal to that of unwelded material of the same analysis in the normalized condition. Thus, assemblies consisting of heat-treated end fittings flash welded to a normalized tube will, in general, require no subsequent heat treatment, provided the normalized tube is sufficiently strong. If a uniform strength at a higher value than normalized is required, then heat treatment is recommended after welding, unless exhaustive tests prove otherwise. This acceptance of flash welds at 100% of the full strength of the parent material gives this process a weight-saving advantage over gas or arc welds which are frequently considered, by aircraft design engineers, to develop a joint efficiency of 80%.

The preliminary test results had been so favorable that the design engineers had not waited for complete results, but had released a number of new assemblies. Consequently, production had reached a level so that severe problems in respect to process control arose. Operator training was perhaps one of the most serious of these. In order to produce parts which would meet the tolerance requirements, the operator must be able to read the blueprint, the machine calibration charts developed as a result of the tests, and have the mechanical ability to make precise adjustments on the machine. The major part of the solution to the operator training problem came as the result of eliminating the use of calibration charts. This was accomplished through the establishment of "setup" cards for each job, on which appear the correct settings for all the machine variables (see Fig. 1).

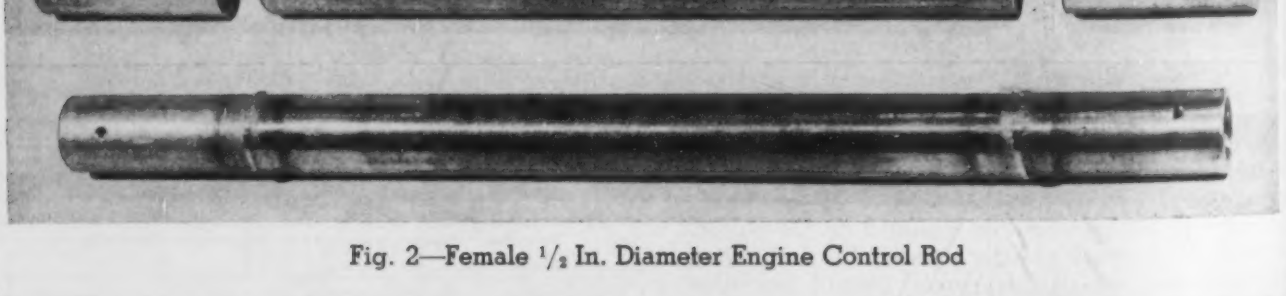

Fig. 2—Female $^1/_2$ In. Diameter Engine Control Rod

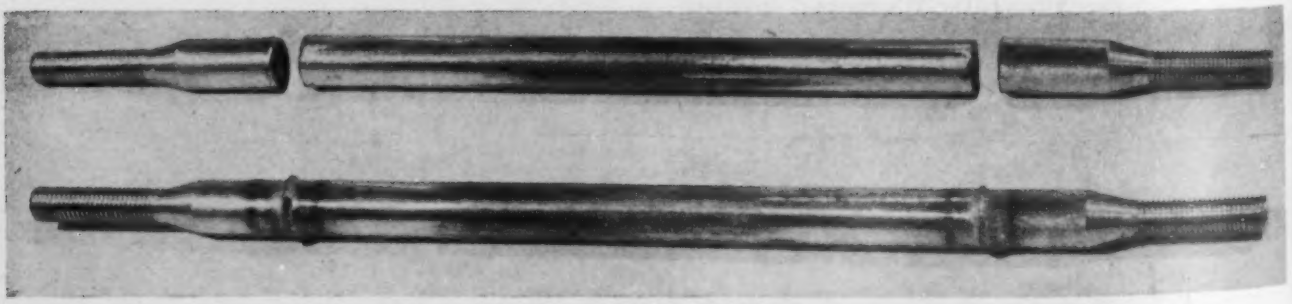

Fig. 3—Male $^3/_8$ In. Diameter Engine Control Rod

Fig. 4—Flash Welding Control Rods

A control procedure somewhat similar to that customarily used for spot welding was established. Test coupons are to be made whenever a new setup is made. These are checked for alignment, appearance, material loss and weld quality. The action of the machine is carefully observed so that discrepancies in setup technique can be detected. The usual test coupon consists of a weld joining two pieces of tubing, each 6 to 8 in. long, of the proper size. The choice of tubing for this purpose does not exactly reproduce the true production welding conditions, but the results of these checks have been very reliable. The usual weld quality check is to load the test coupon to destruction in tension. It is required that the coupon shall break outside the weld-affected area for the setup to be approved for production parts. These checks are repeated at intervals not to exceed 2 hr. The results are recorded on the bottom half or back of the setup card mentioned previously.

As production increased, greater variation in the dimensions of the unwelded details was noticed. For the parts to be usable after flash welding, steps must be taken during the flash welding process to partly compensate for errors made in preliminary machining. Such compensation must, of course, be in the nature of a deviation from an approved setting, hence a doubt is raised as to the quality of the weld. This implies the need of some reliable method of inspection for weld quality.

Both magnetic and X-ray inspection have been tried, but have proved accurate only when the weld can be machined free from flash material. In the case of tubular assemblies, it is often impossible to clean up the inside by machining, and therefore, extreme caution must be used to avoid rejecting sound parts when such inspection methods are used.

The problem of inspection has been met fairly satisfactorily by proofloading all parts to which a load can be applied. The manner of loading and the load used are for the exclusive purpose of testing the weld, and bear no relationship to the function of the part in the airplane. Sometimes it may be a bending or a torsion load, but most frequently it is a tension load. In any case, the load applied is 60% or less of the minimum ultimate strength which the part would develop if the weld were sound. Although this proof load is usually quite different from the load in service, it is very carefully calculated so that there can be no danger of damage to the parts. Records are kept so that possible cause of defective welds may be traced by noting where trouble appears most frequently. Our records indicate that from one to five flash welds per thousand normally fail in proofloading.

The flash welding production rate is fairly high. Two welds per minute are not exceptional for small parts, while 15 to 20 welds per hour can be expected on the larger parts. This rate gives rise to frequent setup changes, since the number of like parts is fairly small. Releases of 500 like units would be considered large.

This condition in aircraft flash welding is one which will probably always exist. In peacetimes fewer parts are needed, while in wartimes, the amount of material which can be tied up in any one assembly is closely controlled. We believe insufficient attention among equipment manufacturers has been paid to this problem. In our opinion, much improvement could be made in the methods of holding the clamping dies in place, leading to increased speed in installation and accuracy of adjustment with which they can be lined up. In our experience, no set of dies has even been installed in a flash welder without needing some adjustment. If provision for fast, accurate adjustment of these dies

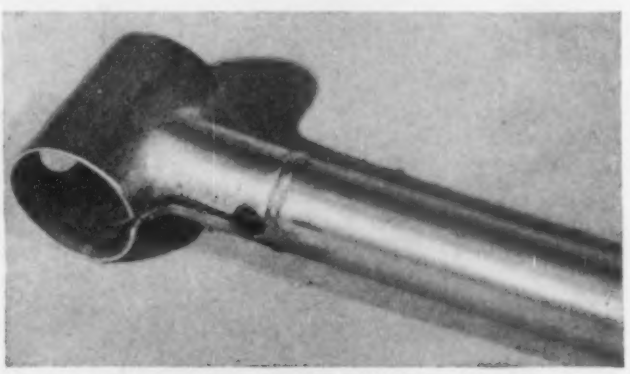

Fig. 6—Flap Actuating Rod with End Fitting Formed from Sheet Material

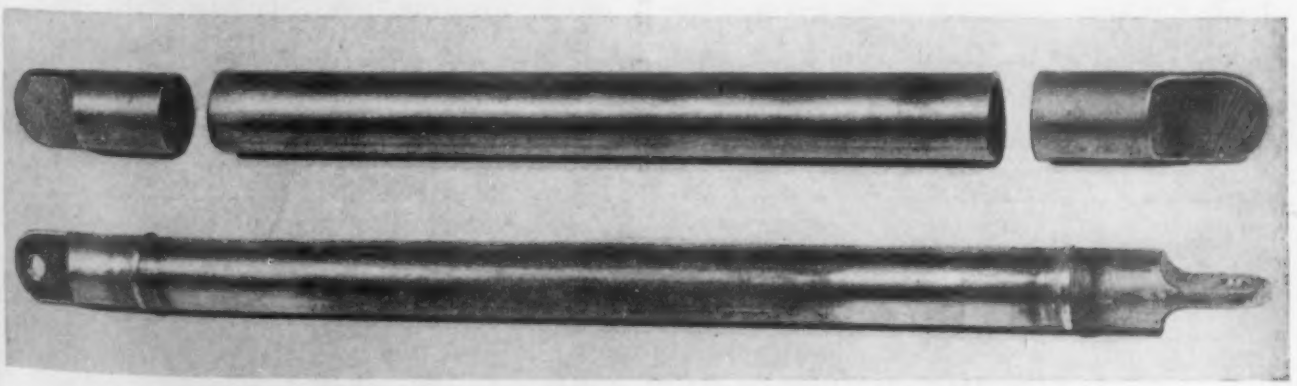

Fig. 5—Oil Cooler Support with Ends Which Must Be Properly Rotated

could be incorporated into the machine design, perhaps through arranging a horizontal, a vertical and a swivel adjustment of the entire stationary platen by means of a calibrated worm screw for each, 50% of the entire setup time could be saved. Another 25% saving in setup time could be accomplished by equipping the machines with precision back stops. These should be designed so that special locating fixtures could be installed in a minimum time, and yet be sturdy enough to withstand the full upset pressure. Extreme care in the design of this item is warranted, in that clumsy design may limit the usefulness of the machine through interference with the parts to be welded, while inaccurate alignment will not permit holding the required tolerance.

At the present time, most aircraft flash-welding applications are S.A.E. X-4130 steel. The majority of the assemblies consist of end fittings welded to tubing. In a few cases, two forgings of irregular section have been welded together, and some promising experimental work has been done with matched steel pressings. The flash welding of extremely long lengths of sheet stock has been avoided because of the expensive specialized equipment required.

Although it is occasionally necessary to normalize a flash weld assembly in order to facilitate machining, considerable time is saved by eliminating unnecessary heat treatment with its resultant warpage.

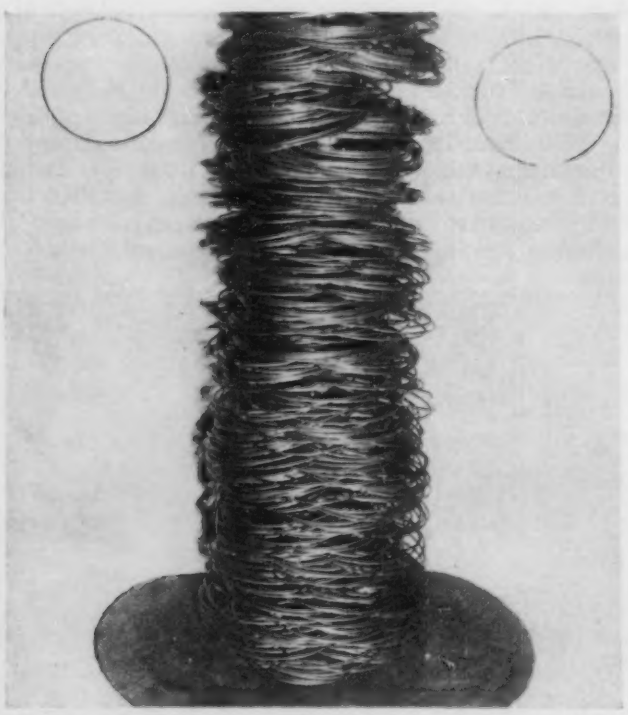

Fig. 7—Wire Rings. Large Quantities Cut Down Setup Time

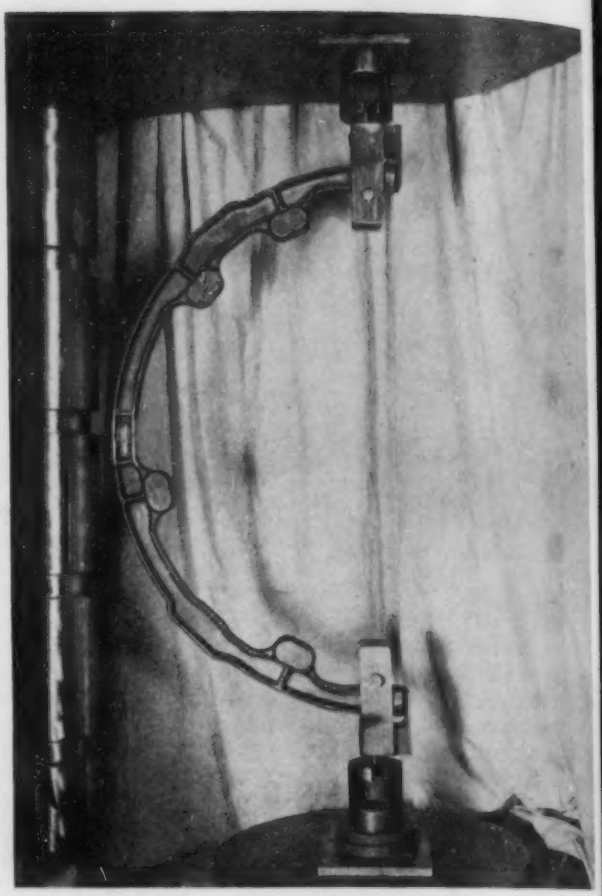

Fig. 9—The Proofloading of a Flash Welded Engine Ring Forging

On assemblies which have become hermetically sealed as the result of flash welding, pressure relief holes should be drilled prior to any heat treatment, to remove danger of bursting due to internal pressure when heated. If heat treatment is unnecessary, such holes need not be drilled, and since the amount of oxygen and water vapor within a hermetically sealed assembly is limited, corrosion caused from them is negl gible, and no internal protective coating need be applied.

In Figs. 2 and 3 are shown two types of control rods. Such assemblies, varying only in length, are used by the hundreds in aircraft production. Either a 10- or 20-kva. machine can be used satisfactorily for the production of these parts. The actual welding of the parts shown in Fig. 3 is illustrated in Fig. 4. The part is $^{3}/_{8}$ in. outside diameter, with a wall thickness of thirty-five thousandths. Three-sixteenths of an inch travel, including upset, taking place in approximately one second, is used. A distance of $^{3}/_{16}$ in. separates the moving and fixed clamping dies at the end of the weld cycle.

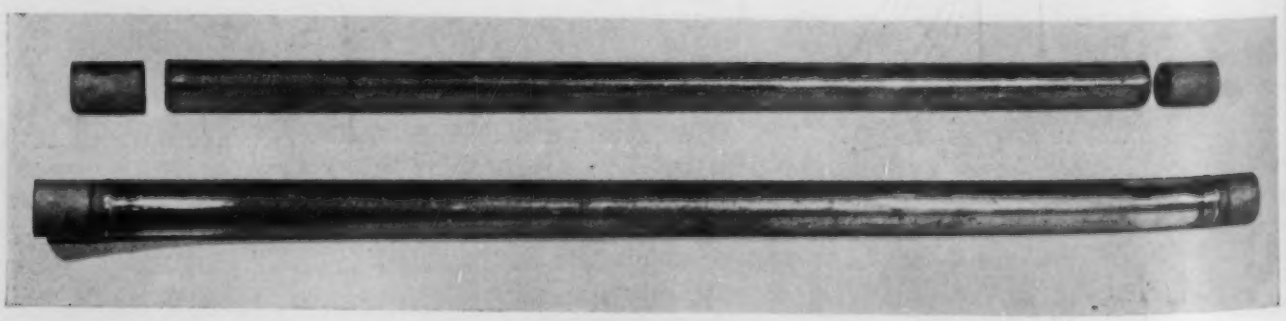

Fig. 8—1 $^{1}/_{8}$ In. Diameter Strut for an Engine Mount

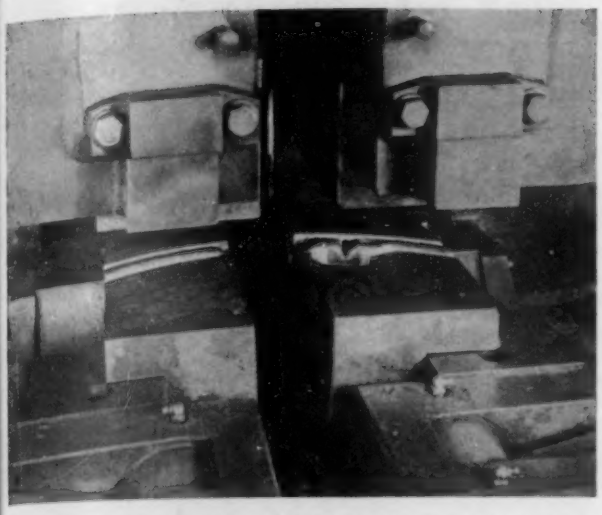

Fig. 10—The Dies Used for Welding the Engine Ring Forging

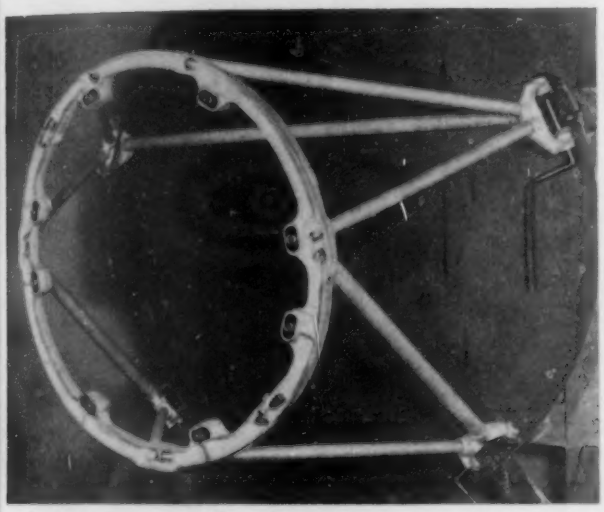

Fig. 11—The Engine Mount Assembled from Flash Welded Details

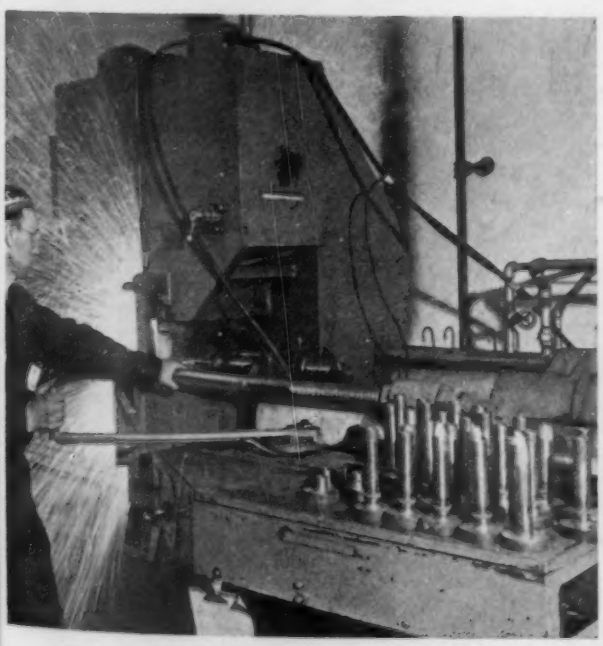

Fig. 12—The Flash Welding of Hydraulic Pistons

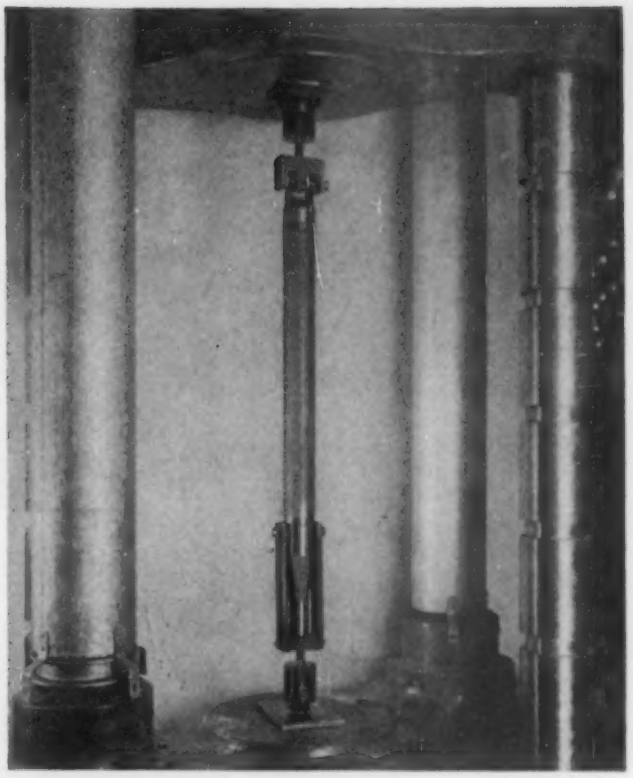

Fig. 13—The Proofloading of a Flash Welded Landing Gear Strut

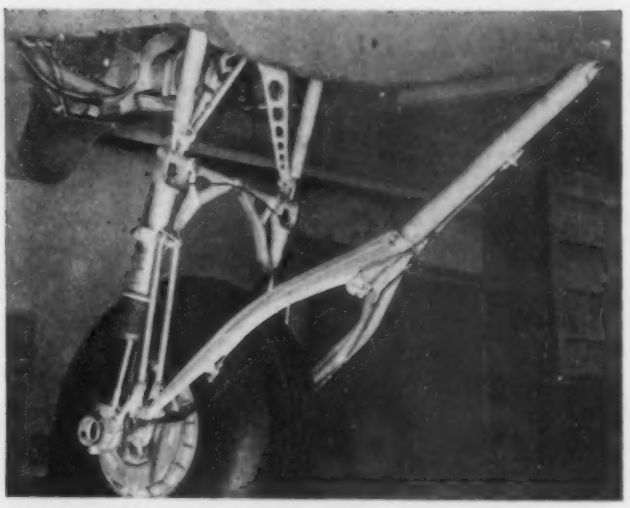

Fig. 14—This Landing Gear Utilizes Seven Flash Welded Members

Although S.A.E. X-4130 steel is used, no heat treatment is required after welding, for this assembly.

Figure 5 shows an oil cooler support. This assembly is quite similar to the control rods, except for the type of end fittings. In welding this assembly, special locating fixtures which hold the rotational relationship of the end fittings are attached to the machine.

In Fig. 6, a flap actuating rod, the end fitting has been pressed from sheet material so that a tubular section has been formed. This permits easy flash welding. The welding conditions are quite similar to those stated for the control rods.

Figure 7 shows a quantity of flash-welded reinforcing rings. These rings are made from $^1/_8$-in. diameter mild steel wire. The flash welding of the large quantity shown, at one release, has avoided the lost time occasioned by frequent setup changes necessitated by small releases.

Fig. 15—A Flash Welded Bracket Assembly

Figure 8 shows the details of a flash-welded engine mount strut. This assembly consists of heat-treated S.A.E. X-4130 ends flash welded to normalized S.A.E. X-4130 tubing. Fatigue tests have demonstrated that subsequent heat treatment is unnecessary. However, in order to hold the close tolerance on length and the accurate alignment of the tapped holes which are placed in each end, the finish machining is performed after flash welding. Figure 9 shows a flash-welded engine mount half ring in the jig which is used for proofloading. In this case, two matching forged sections are welded. In Fig. 10 is shown the flash weld machine clamping die arrangment used for this application. Figure 11 shows the complete engine mount assembly. The forged ring in the picture was not flash welded. Difficulties in procurement of the one-piece forging gave rise to the welded construction.

Figure 12 shows a view of a flash weld machine in

Fig. 16—The Flash Welding of the Bracket Assembly

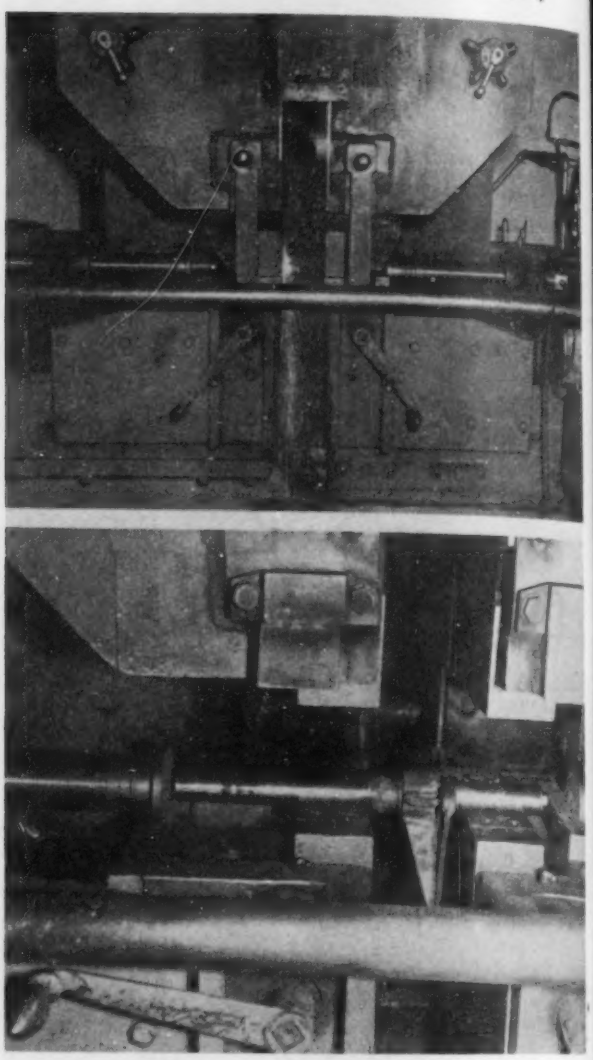

Fig. 17—The Bracket Assembly in the Machine Just After Welding

operation. In this case, the part being welded eventually becomes a hydraulic piston assembly. Provision is made for finish machining after welding to hold the required tolerance.

Figure 13 pictures a landing gear member in the jig

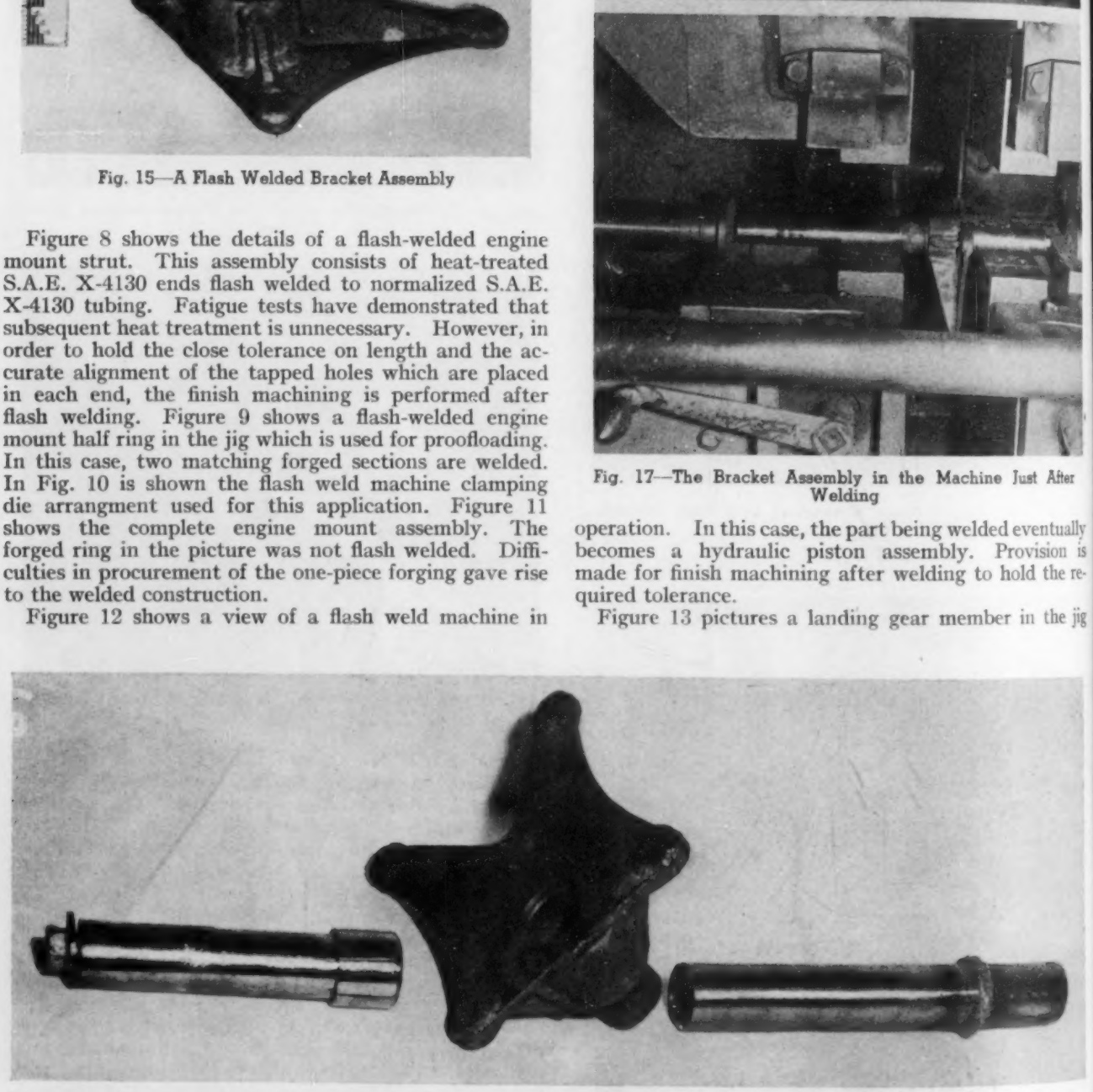

Fig. 18—The Copper Alloy Mandrel (Left) Solved the Clearance Problem When Flash Welding the Bracket Assembly

Fig. 19—Total Material Loss—Steel Tube

Tubing O.D.	Wall Thickness												
	0.035	0.049	0.058	0.065	0.072	0.083	0.095	0.109	0.125	0.156	0.187	0.216	0.250
5/16	3/16	7/32	7/32	7/32	7/32	1/4	9/32						
3/8	3/16	7/32	7/32	1/4	1/4	1/4	9/32	9/32					
7/16	7/32	7/32	1/4	1/4	1/4	1/4	9/32	9/32					
1/2	7/32	7/32	1/4	1/4	1/4	9/32	9/32	5/16	5/16	3/8			
9/16	7/32	7/32	1/4	1/4	9/32	9/32	9/32	5/16	5/16	3/8			
5/8	7/32	1/4	1/4	9/32	9/32	9/32	5/16	5/16	3/8	3/8	7/16		
3/4	7/32	1/4	9/32	9/32	9/32	5/16	5/16	3/8	3/8	7/16	7/16	7/16	1/2
7/8	1/4	9/32	9/32	5/16	5/16	5/16	3/8	3/8	3/8	7/16	7/16	1/2	1/2
1	1/4	9/32	9/32	5/16	5/16	3/8	3/8	3/8	3/8	7/16	1/2	1/2	1/2
1 1/8	9/32	5/16	5/16	5/16	5/16	3/8	3/8	3/8	7/16	7/16	1/2	1/2	9/16
1 1/4	9/32	5/16	5/16	3/8	3/8	3/8	3/8	7/16	7/16	1/2	1/2	9/16	9/16
1 3/8		5/16	5/16	3/8	3/8	3/8	7/16	7/16	7/16	1/2	1/2	9/16	9/16
1 1/2		5/16	3/8	3/8	3/8	3/8	7/16	7/16	7/16	1/2	9/16	9/16	9/16
1 3/4		3/8	3/8	3/8	3/8	7/16	7/16	7/16	1/2	1/2	9/16	9/16	5/8
2			3/8	3/8	7/16	7/16	7/16	1/2	1/2	9/16	9/16	5/8	5/8
2 1/4				7/16	7/16	7/16	7/16	1/2	1/2	9/16	5/8	5/8	11/16
2 1/2					7/16	7/16	1/2	1/2	1/2	9/16	5/8	5/8	11/16
2 3/4						1/2	1/2	9/16	9/16	5/8	5/8	11/16	11/16
3							1/2	9/16	9/16	5/8	11/16	11/16	3/4
3 1/4							1/2	9/16	9/16	5/8	11/16	11/16	3/4
3 1/2							9/16	9/16	9/16	5/8	11/16	3/4	3/4
3 3/4								9/16	5/8	5/8	11/16	3/4	13/16
4								9/16	5/8	11/16	11/16	3/4	13/16
4 1/4									5/8	11/16	3/4	3/4	13/16
4 1/2										11/16	3/4	13/16	13/16
4 3/4										11/16	3/4	13/16	13/16
5										3/4	3/4	13/16	7/8

used for proofloading. Figure 14 shows the landing gear assembly. Seven flash-welded members are used in making up this gear. Because of the strength requirements, all the parts in this case are heat treated after flash welding. In order to hold the close dimensions, the finish machining is done after the heat treatment.

In Fig. 15 is shown a bracket assembly completed except for machining. Figure 16 shows this assembly receiving its second weld. Figure 17 shows the assembly in the machine just after the welding is completed. Note that a mandrel was used to hold base of the bracket in alignment. This mandrel was made of copper alloy, and also carried the welding current. Figure 18 shows the mandrel, the base plate and the tube on which the end has already been welded. This picture shows the head of the draw bolt by which the mandrel is expanded after it is inserted into the hole in the base plate. This welding technique is used because of clearance problems on the machine.

In conclusion, it seems advisable to review briefly the exact procedure used for setting up a new flash weld job. The values given are typical for S.A.E. X-4130 steel:

1. Test coupons representing the job are procured. These are cleaned by sandblasting or pickling to provide good electrical contact.

2. The machine is set up to give the total travel required (see Fig. 19). From 20 to 35% of the total travel will be upset travel. The exact value will be determined experimentally.

3. The closed position of the clamping dies for most jobs will be as near together as possible, to aid in maintaining alignment. Space must be left for the upset to form. A minimum value for this is $^3/_{16}$ in. for thicknesses under forty-thousandths of an inch; for each additional forty-thousandths in thickness, add $^1/_{64}$ in.

4. Adjust the speed and current for steady vigorous flashing. A good preliminary speed setting will cause the flashing travel to take place in a time equal in seconds to about five times the area of cross section in square inches.

5. For some parts, particularly those with a wall heavier than $^1/_{16}$ in., some benefit may arise from beveling the end of one of the parts. The exact shape of the bevel is not critical. Its purpose is to prevent two perfectly matched machined surfaces from coming into contact, and because of their good current-carrying capacity, preventing flashing from starting.

6. Trial welds are made until the external appearance is satisfactory. Some of the welds are then subjected to tensile loads, while others receive metallurgical examination. If the results of these tests are satisfactory, the final setting is recorded on the setup card, and production proceeds.

Machine Cutting for Assembly Line Fabrication*

By C. O. Adams†

Introduction

AS A part of the tooling program to produce generators in quantities for Diesel electric units required in our war effort, a fabrication assembly line was set up for the oxygen cutting, forming, assembly and welding of steel plate to make the main frames and other fabricated parts required in these generators. The oxygen cutting machine has taken its proper place in this line as a machine tool. Several standard machines were employed, as well as some special applications of machine cutting.

There are certain requirements which any machine tool must meet to be applicable to such a production line where a variety of similar, yet different sized parts are made. These were considered both for the standard cutting machines as well as the special applications of machine cutting torches.

The use of these machines involved problems in tooling, processing and production which were similar, but different in detail, to our previous experience in production operations. The purpose of this paper is to present these applications of machine cutting to assembly line fabrication and some of the problems encountered, since similar thought must be given to any production fabrication setup involving machine cutting.

General Requirements

In general, the oxygen cutting machine has to satisfy the same requirements expected of any machine tool for productive operations. It has to be capable of consistent repetitive operation by semi-skilled or even unskilled operators within a production line sequence of operations. The cutting machines available today satisfy these conditions. They are flexible enough to permit the various setups required without excessive delay time. They are rugged enough for continuous operation, although there is room for improvement in this respect. Just as any other machine tool, they can be provided with templates and fixtures for rapid handling of repetitive work.

For productive operations, templates and fixtures permit the successful operation of these machines by semi-skilled or even unskilled operators. A magnetic tracing head can be set to guide the torches, following the outline of a machined template. The cutting speed, oxygen and preheat gas pressures, and tip sizes can be established by a job setter. Thus one trained cutting operator can be responsible for operating several machines. The actual machine operator starts and stops the machines and the cutting gases and handles the work. The training required for any particular cutting operation can be gained quickly under the guiding hand of the job setter, right on the job. This method of operation has been a decided help in the war effort due to the lack of skilled operators.

The cutting machines required for these operations satisfied the layout requirements for sequential line operation very well. A large travograph cutting machine established the starting end of the line, since the first operation had to be the cutting of large steel plate. This was convenient to the adjacent steel storage location. The majority of steel cut was moved from the travograph to the next operation on a roller conveyor to facilitate handling and to provide the necessary moving storage bank of stock.

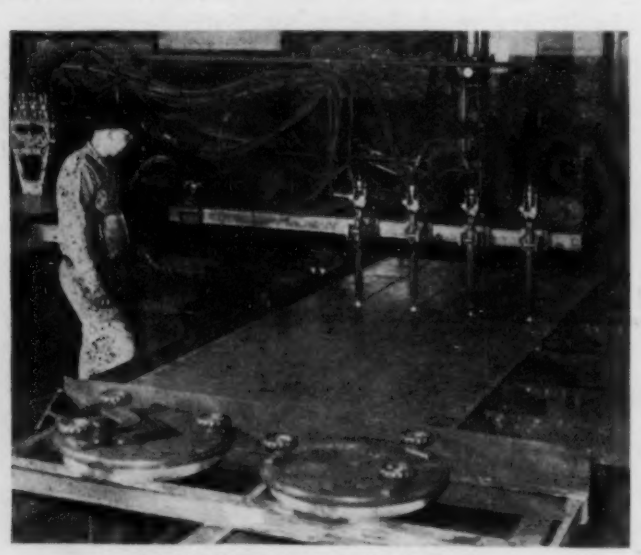

Fig. 1—Shape Cutting Frame Blanks

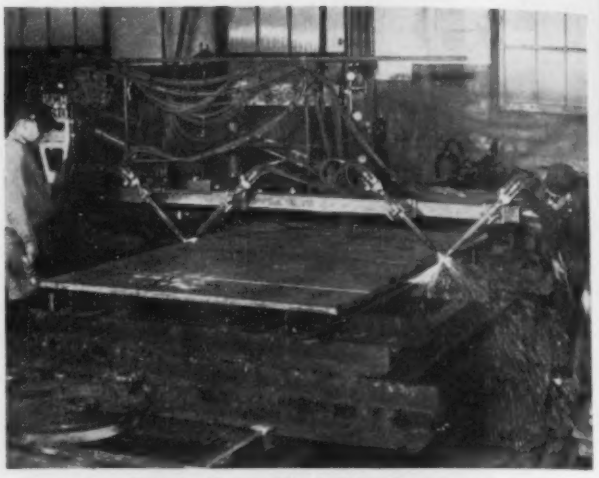

Fig. 2—Frame Blank Edge Preparation

* To be presented at the Annual Meeting, A.W.S., Chicago, Ill., Oct. 18 to 21, 1943.

† Welding Engineer, Delco Products, Division of General Motors, Dayton, Ohio.

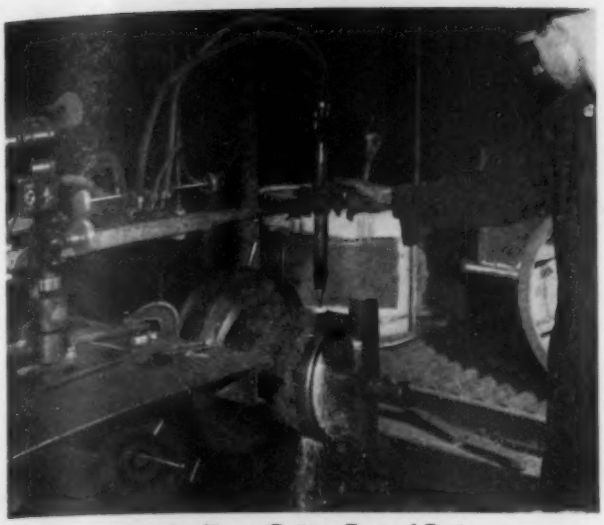

Fig. 3—Shape Cutting Formed Part

A smaller machine of the planograph type was also located near the head of the line to feed small parts into the inspection location at this point, ready for assembly. The oxygen machine cutting of partially fabricated units was established within the production line at the required locations for sequential operation. Beveling and turning operations were set up on special machines with torch holders mounted over welding positioners. One operation was set up as a combination of a welding positioner and a standard planograph.

Shape Cutting of Production Parts

All large plate sections are cut on the travograph. Heavier handling equipment is necessary for the plates prior to cutting into parts ready for assembly. Here the use of large templates, clamping devices and plate locators are the principal provisions for insuring accuracy in repetitive operations. Multiple torch straight-line cutting has proved satisfactory for cutting the frame blanks to width for the heavier plate sections where close accuracy is not a definite necessity, as will be seen later. This operation is shown in Fig. 1. For this operation the torch supporting bar is locked to the machine carriage and the cuts made parallel to the track of the machine. The plate is lined up with the track by means of locating stops which are removed when the plate is in position. At present, the frames are being cut to length in the same way. However, this operation may be eliminated in the near future, when it may be included in the beveling operation. Some frame blanks require shape cutting in addition to the outside periphery cut. Where this is required, a combination template is provided to make both the outside and the inside cuts. Although this calls for an extremely large template, the ability to reproduce identical parts with semi-skilled operators has justified this expense. In fact, the relative consistency of frame lengths from these templates and its effect on subsequent operations has caused serious thought of using templates for all frames, whether there is a need to locate inside cuts or not.

Although the principle use of this machine is for the cutting of frame blanks to start down the fabrication line, it is also used for shape cutting of parts too large to be conveniently cut on the smaller machines. This includes, in particular, a large ring with notches cut into the outside diameter. The shape of the notches precluded cutting them at the same time as the outside diameter. In doing this in two operations, the rings are first cut from plate stock, then located on a centering fixture and notched. Both operations are performed from templates and using multiple torches. Rapid setting of the torches is provided by centering the tracer on the template and setting the torches by means of center holes in the plate locating fixtures, lowering the cutting tips into these holes for accurate alignment.

Some shape cutting is being done on partially fabricated units within the actual assembly line. This is being done only where the angles of the cuts with respect to formed plates Fig. 7, preclude the possibility of making these cuts in flat plates before forming. The difficulties of positioning the work for such cuts and the locating problems associated with the use of templates and machine cutting make it advisable to avoid this wherever possible. Where it is necessary, a combination of a planograph and a welding positioner is being used successfully. One interesting application is shown in Fig. 3, where parallel, instead of radial, cut edges are required in a round formed plate section.

Most of the small parts required in the assemblies are cut on the planograph at the head of the line as mentioned above. Here again the use of machined templates, magnetic tracing head and multiple torches has enabled the rapid repetitive shape cutting of production parts. For precision cutting, it is necessary to consider the proper kerf allowances and plate distortion in making the templates, and careful control of the tip sizes, procedure control and quality of cutting performed by the operator. Without experienced operators, this places a rather large responsibility on the job setter. As was mentioned above, however, it is not too hard to train the operators for single, repeated operations, such as shown in Fig. 4.

Because of the necessity for accurately cut parts, and the multiplicity of possibilities for occasional mistakes during the operator training periods, a piece part inspection of small torch cut parts is helpful both to assembly and in the operator training program. The use of either outline gages or master parts which have been carefully measured enables the inspection department to rapidly check production parts prior to their routing to assembly stations.

Plate Edge Preparation of Flat Plate

The plate edge preparation required on parts shape cut from plate is accomplished before their introduction

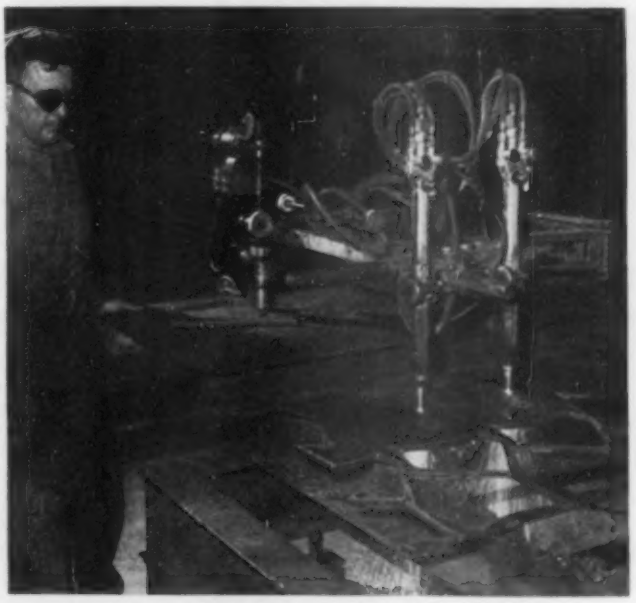

Fig. 4—Multiple Shape Cutting Small Parts

into the assembly line. The frame blanks are the principle items which require beveling on a large scale. Where a double bevel with land is required on opposite ends of the plate, this is acomplished by a multiple torch setup on the travograph. As shown in Fig. 2 our method of doing this is to cut the plate to length as required, using multiple width plate, and then beveling with four torches, two mounted on the cutting bar at each end of the plate. This method requires careful attention of the operator to maintain tip adjustment but has given very satisfactory results. However, a floating trailer setup should give better results where plates are not perfectly flat, providing the roller support is mounted as close as possible to a multiple tip arrangement. In making short bevel cuts where double bevels are required, it is more practical to use a single torch in several positions, the set-up and tip adjustment time for the multiple torch arrangement usually being greater under these conditions.

The need for stable torch carriage bars is more pronounced in beveling than in straight cutting. The impingement angle of the preheat flames causes erratic preheating from very slight disturbances in the torch movement. This, in turn, causes irregular or rough beveled surfaces and in some cases even the loss of the cut. There is room for improvement in stabilizing the torch motions of cutting machines for all precision cutting, either straight or beveling.

For either single torch beveling, or two torch beveling without simultaneous cutting of the land, the plate edge must be carefully aligned with the path of the torch or torches. This is necessary to obtain consistent bevel size. Line-up bars or blocks on the cutting tables expedite this plate alignment where numerous plates must be cut on the same setup.

Small parts to be beveled which are easily handled and set up are cut to better advantage on the planograph. The same essential considerations of the torch alignment and stability mentioned above are applicable to the planograph.

Highly repetitive beveling of the ends of long bars is done more readily by the "jeeps" of the cutting line, the radiograph, than by the large stationary machine, since only a limited cutting movement is required. Most of the beveling of the bar ends is done by a single torch setup. However, as a repetitive operation on a large scale, it will be advantageous to arrange special multiple tip sets for the various bar sizes and shapes.

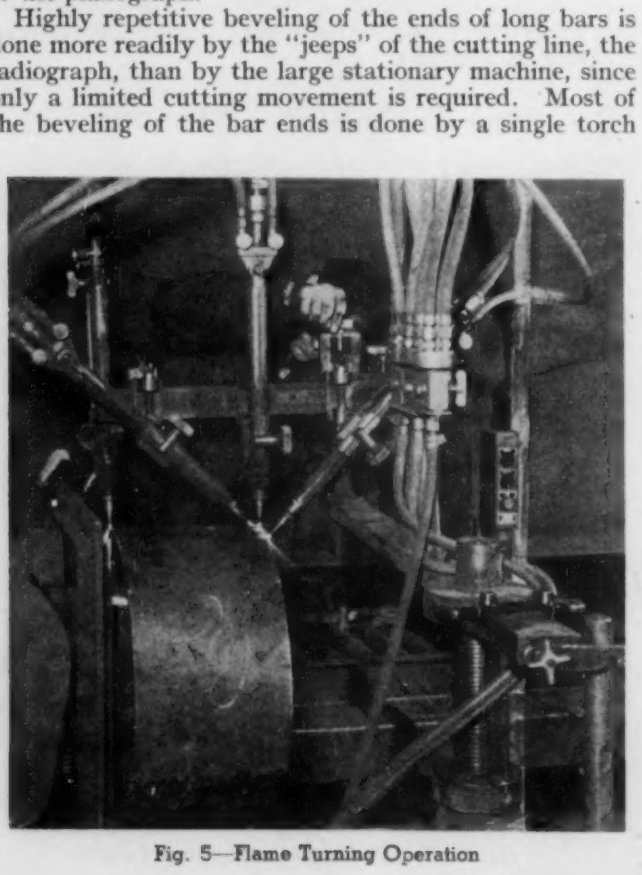

Fig. 5—Flame Turning Operation

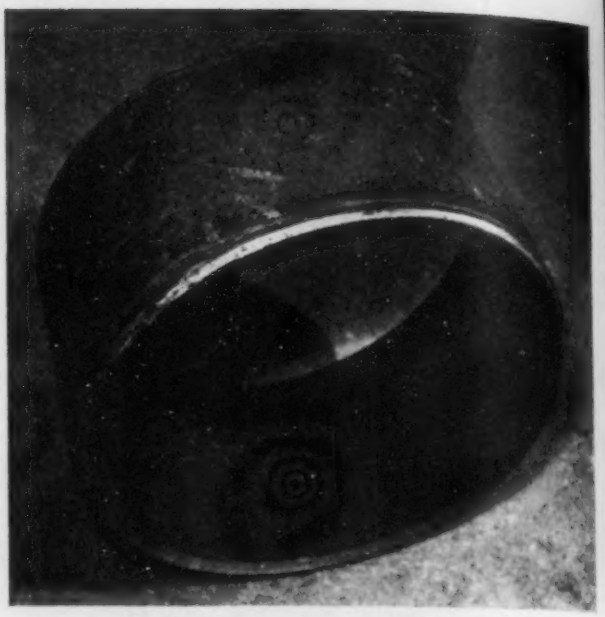

Fig. 6—Frame as Bevelled and Squared

It should be noted here that even though the line has been set up for machine cutting of all production parts, it is occasionally necessary to bevel bar ends on one or two special pieces at odd times. Here the hand torch still takes its place, rather than disturb a production setup on the machines.

Slag removal is sometimes overlooked as a part of plate edge preparation both in straight and bevel cutting. However, it cannot be overlooked in a production line setup, since provisions must be made to remove slag from cut edges before assembly and welding. Slag cleaning, when done on the machine tables, reduces available machine capacity. If done off these tables, space or equipment must be provided on the floor layout of the fabrication and assembly line.

From the standpoint of slag removal costs, some balance can be obtained by sacrificing part of the cutting speeds to have less adhering slag. This must also be considered along with the quality of cuts required. When the cutting speeds are maintained to obtain exceptionally smooth cut edges, a minimum of slag will be encountered.

The slag adhering to the larger parts must necessarily be removed by hand tools. But several other methods are available for smaller parts. Rough grinding wheels and tumbling barrels are both effective, depending on the number of parts involved in any one order.

Plate Edge Preparation of Partially Fabricated Units

Machine torch beveling has been used to replace boring mill operations for beveling circular sections, permitting this operation to be included within the fabrication setup. By rotating the parts under a stationary multiple torch setup similar to that used for beveling on the standard cutting machines, it has been possible to obtain bevels and over-all dimensions comparable to that formerly obtained on large boring mills. In Fig. 5 is seen a four-torch setup which bevels and cuts a round frame barrel to length, at the same time squaring these cuts with the axis of the frame, Fig. 6. By maintaining a fixed torch setup, the uniformity of parts required for production assembly is easily maintained.

Fig. 7—Frame Showing Angled Shape Cuts

The multiple torch arrangement for circumferential beveling has considerably reduced the cutting time below that required by the previous turning method.

As was noted above, for occasional beveling the hand torch takes its place. Just so in the beveling required on certain partially fabricated units, it is easier to use a hand torch for minor edge preparation than to arrange to locate the unit under a cutting machine. This has been found economical in several locations in the assembly line.

Scheduling of Machine Cutting Operations

Careful scheduling of machine cutting operations is necessary to maintain an economic balance between setup costs, daily schedule fluctuations, available material and storage facilities in sequential line operation. This is particularly true in multiple torch operation where the setup requires an appreciable length of time to locate templates, torches and work locators. Here the maximum possible run on any one assembly must be scheduled through the entire line to reduce the setup cost per piece for the cutting operation. Storage space to work the cutting machines ahead of the rest of the line is dependent on the original space available for the layout. It should be emphasized that here the original floor plan layout can affect the ultimate operating efficiency of the large plate cutting machines. This ultimate efficiency will also be affected by the provisions made for material handling. Conveyors for removing the cut pieces must be assisted by adequate lifting facilities to move the plate onto and from the cutting table. These factors must be considered in scheduling, as well as the finished, fabricated units required. Adequate time must be provided between the torch-out schedule and the fabricated parts schedule so that all of these factors may be considered and the number of setups for small quantities reduced. One factor in war production which is hard to reconcile to a proper schedule is the apparent inability to match all material schedules on incoming metals with required production schedules. This is the factor which causes the daily schedule fluctuations mentioned above.

The cutting schedules arrived at by the above must be broken down in proper sequence to maintain the proper flow of cut parts to match the line fabrication schedules, or rather to initiate the line schedules. The person responsible for the cutting operations can then schedule the setups through the day so that the job setter can prepare the machines for the production operators. This must be made separately available for both large and small machines ahead of the line. The cutting operations within the line have been arranged to take any partially fabricated unit as it comes down the line.

The required schedules must be carefully checked against the available steel, since under present conditions this may cause a change of plans almost daily.

Relationship of Cutting to Fabrication Time

Two aspects of machine cutting affect the fabrication line efficiency. The cutting accuracy directly affects the assembly and welding time studies, and the cutting schedules affect the possible delay factors. Accurately cut parts reduce the time required to obtain good fit-up for the welded assemblies. This proper fit-up, in turn reduces the time required for the welding operator to obtain the required weld sizes and quality. After obtaining this good fit-up, the assembler loses no time placing parts in the welding jigs and fixtures when there are no irregular edges to grind or polish. This is the final goal of the above-mentioned templates and jobsetter control of all cutting operations.

In addition to the factors requiring accurate shape cutting, accurate beveling is required in plate edge preparation to permit proper weld penetration in beveled joints without excessive weld metal deposited. A reduction in the bevel angle will make it difficult for the welding operator to make the required joint, while increasing the bevel angle beyond that called for in the design, will increase both the welding time and the welding rod required.

Any adhering slag on the parts ready for assembly either affect the fit-up by maintaining false part dimensions or by requiring the assembler's time for its removal. If this is missed by the assembler, it causes the welding operator to lose cleaning time and makes it more difficult to obtain a sound weld over the slagged edges.

The effect of any or all of the above time losses is to make faulty the scheduling based on normal time studies. This may have two disastrous results. The loss in efficiency may increase the cost of the part above the contract price. It may also prevent meeting contracted schedules. This, in wartime, is the more serious of the two effects. Careful attention to all the details of the oxygen cutting operations will pay the same dividends as similar attention to the details of metal turning machines in reducing costs and meeting schedules.

Summary

The oxygen cutting machines are applicable to production operations without highly skilled operators. They have been set up for repetitive shape cutting of both large and small parts on an assembly line basis, as well as shape cutting on partially fabricated units, all from machined templates for accurate reproduction. Plate edge preparation for beveled joints has included fabricated parts formerly machine turned, as well as normal mutliple torch beveling operations on flat stock. Careful scheduling of the cutting operations is necessary to help reduce costs and maintain schedules of the fabricated units. Care and accuracy in all of these operations, along with careful cleaning of cut edges, is essential to efficiency in the assembly operations.

Transition from Riveted to Welded Construction of Light Combat Tanks*

By William Osha† and John W. Sheffer‡

THE riveted light combat tanks which were placed in production in 1940 have given a good account of themselves.

In Buna, when in final assault on the Jap stronghold in New Guinea, the "Aussies" supported by a light tank, sprayed bullets on the fleeing Japs after their pill box was smashed by the tank.

On Guadalcanal, U. S. Marines pause on the beach in the Solomons before advancing inland against the Japs, light combat tanks were landed with the men.

In Libya, a group of light tanks were held in reserve ready for action. According to British information services, "Four American built light tanks were the first vehicles of the victorious British Eighth Army to lumber into Tripoli when the Capital of Italy's African Empire fell on January 22, 1943." The four tanks, manned by officers and men of Britain's famous Eleventh Hussars Regiment, were "Jeb Stuarts." Records identified these tanks from the numbers furnished by British information services as tanks which were delivered in the late summer of 1941.

In Russia, the light combat tank is called General Suvorov. This first photograph to emerge from U.S.S.R. shows four of these tanks crossing a mountain river in the Northern Caucasus.

In the Aleutians, in the frigid north, arctic snows prove no obstacle to the light combat tanks. Wherever they are found they "can dish it out and take it."

In the near East, train loads of light combat tanks were moved to the fighting front.

This introduction of the light combat tank shows its service and wide distribution in this globular war.

* To be presented at The Annual Meeting, A.W.S., Chicago, Ill., Oct. 18 to 21, 1943.

† General Welding Foreman, Berwick, Pa.
‡ General Electrical Engineer, American Car and Foundry Co., New York, N. Y.

However, the subject of principle interest is the construction of this tank and the part that welding has played to make it a more effective instrument of war.

In the fabrication of riveted combat tanks, armor plate of various thicknesses, shape and contour was assembled by riveted butt-strap construction. The butt straps were fabricated from structural shapes and strip. The plates were gas cut to shape, then planers and shapers accurately cut the abutting edges to make a tightly fitting joint. Brakes and hydraulic presses form the plates to the desired contour. Holes for riveting are carefully drilled to template.

The fabrication of the welded combat tanks of the same design differs in fabrication by: (*a*) the elimination of the butt straps and the rivet holes in the armor plate for assembly; (*b*) the additional double beveling of the armor plate edges by oxyacetylene beveling machines.

The substitution of the welded joint revised armor plate edge preparation. Oxyacetylene flame shape cutting machines as a production tool relieved the planer and shaper and produced a satisfactory edge and bevel in most cases for the welded joint. The design permitted 90° flame cutting of all plate edges to dimension. Thirty-degree, 45° and 60° beveling in the same plain, when properly guided, furnishes a satisfactory edge for welding.

The gas-shape cutting machine has proved itself more efficient and more economical than planers and shapers; not only in the cutting of 60 pieces of armor plate per tank to shape but also in double beveling a great many of these plates in the welded design. This may not seem impressive for the individual tank, but the gas-cutting machine as a duplicator is most efficient in the production of over 1000 tank sets of armor plate per month for ourselves and other fabricators and assemblers of tanks and half tracks which we supply.

Fig. 1—According to Identification Numbers Four of These American A.C.F. Built Tanks Were the First to Enter Tripoli When the Capital of Italy's Empire Fell on Jan. 22, 1942

Fig. 2—Marines Take Over Guadalcanal Beach. In the Foreground Is a Marine Combat Tank

The application of approximately 80 gas-shape cutting machines of various types to armor plate fabrication required a great deal of patience and perseverance in order to get an efficient setup and economical results.

Ordinarily, sufficient accuracy may be obtained by burning direct from the pantograph rather than from "riding the plate;" arrangement of the cutting so that the torches ride a template attached to the armor plate being cut maintains a tolerance to $^1/_{32}$ in. and consistent duplication. Gas cutting of homogeneous armor need not be followed by flame softening, but welds can be made directly to the gas-cut surface provided all heavy scale is removed by touch grinding.

The combat tank consists of two units, the hull and the turret.

The original turret of riveted design was made up as a polygon with 8 sides from flat armor plates; the 2 long sides focusing toward the front gun shield plate.

Fig. 3—Front Top View of Riveted Combat Tank Built by A.C.F. During 1940

The turret cupola was a 6-sided polygon, 2 sides being vertical extensions of 2 sides of the turret proper.

The assembly of these plates in a strong integrated unit required many miter joints with abutting edges cut very accurately at various angles in a planer or shaper setup.

All plates required in the integral unit were drilled by jig preparatory to assembly by countersunk rivet butt-strap construction. The holes drilled, reamed and rivets driven were 220 per turret.

Some months later, we were asked to weld some armor plate samples. At that time, we knew of no one who had any experience welding face-hardened armor. We called for consultation some of our friends who manufacture welding electrode. After trying several different joints and electrodes, it was finally decided to butt weld with a double-vee joint 2 plates approximately 18 x 36 in. to form a test plate 36 in. square. (This was some time before the H-plate was ever proposed.) The weld was made originally with special electrodes with 2 beads of hard surfacing electrodes on the face side. The ballistic tests of various butt-welded joints (which were primarily for resistance to penetration) had developed a joint 85 to 90% of that of the armor plate itself; the double-bevel butt-welded joint was then substituted for the riveted butt-strap construction on the 8–6-sided polygon turret design.

Fig. 4—"Jeb Stuart" Combat Tank Flowing from the Assembly Line

The jig assembly of these armor plate segments into the 8-sided polygon permitted tacking these plates together after a buttering bead was applied at the root-gap edge before plates were placed in jig, leaving a $^1/_8$-in. separation at the root for the first multiple pass hand welding and a root-gap opening on the inside of 30 to 45°, on the outside of 45 to 60°. This permitted complete penetration of the root passes.

This design, lapping the plates in several positions used a double fillet weld; one on the inside, the other on the outside. The outside fillet with a vertical lap gave little concern from ballistic impacts due to its position. The horizontal lap on the floor in most cases permits double side and edge fillets equal to the thinner plate.

The first welded turret was a quick changeover of a riveted design by double bevel 6 abutting vertical edges and proceeding to weld these joints by the best technique then available for armor plate welding. However, the excess man-hour welding time for multipass double butt welding of 6 seams of approximately 30 in. suggested a turret of new design adapted for welding, wherein 2 semi-cylindrical formed homogeneous armor plates had one vertical double butt-welded joint with the long sides focusing toward the front gun shield plate. The cupola was semi-cylindrical with two vertical butt-welded seams, and horizontal butt and fillet weld attaching same to the turret top. Welded attachment of base ring and guard together with peek door frames created an integrated unit which relieved the concern from the shatter in the riveted turret. This welded design turret served for about a year's production.

A welded turret with a bulge in the rear was put in production early this year. This entirely new design was necessary due to increased space requirements.

The 2 homogeneous formed side plates were gas cut horizontally, the bottom section was formed into a circle to which the base ring is attached. The upper section projects to the rear to form the bulge, also focused forward for attachment to the front gun shield plate. Roof and floor attachments complete the unit.

The attachments just referred to in this design require 4 multiple-pass double butt welds, 2 extending the back plate attachments to the side plates, and 2 extending the side plate attachments to the front plate. Sections through the principle welded joints show from 6–8 multiple passes, 3 of which are hard facing.

Production demands attention to the creation of proper jigs and positioners in order to give the welder every advantage in man-hour output, at the same time produce a weld of the highest quality. Fillet welds continue in use for lap joints and certain attachments such as handles, hoisting eyes, guards, plate reinforcements,

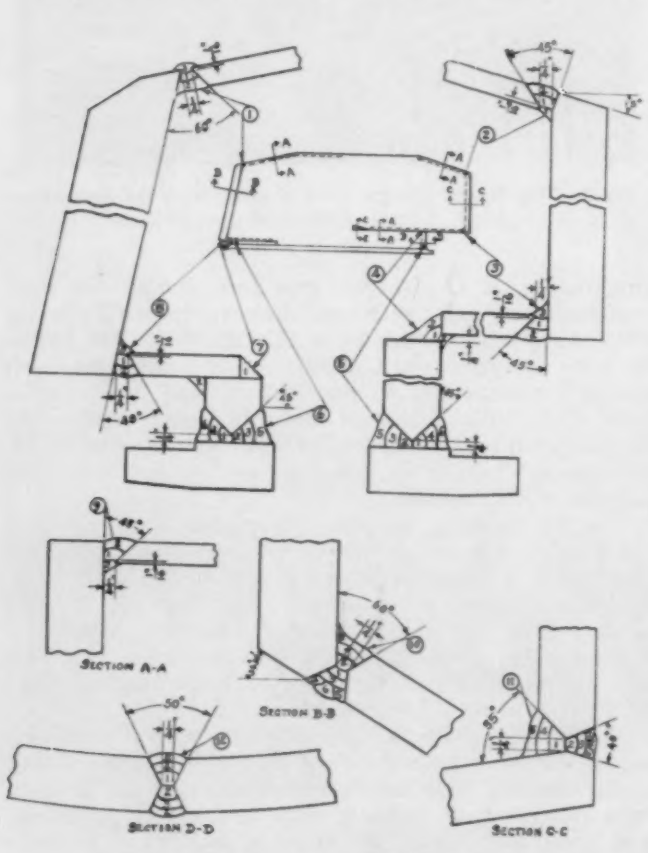

Fig. 5—Welding Sections Through Turret

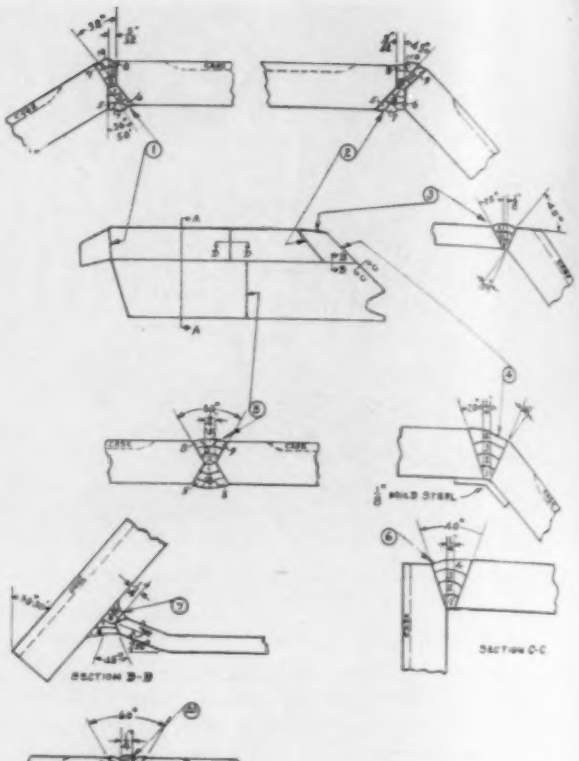

Fig. 6—Welding Sections, Through Hull and Sponson

retainers, segment gussets, strap hinges and supports. These fillets vary in size from $^1/_4$ to $^3/_4$ in.

As we learned more about welding of armor plate, we found that the saying, "A bad welding job is better than a good riveted one," was gradually being heard less and less. Emphasis was being placed on the making of welds that approached the strength of the parent plate. Resistance to penetration was becoming secondary to shock resistance.

In welding face-hardened armor, one is confronted with essentially two metals—the core, which has a low carbon content, and the face, which has an extremely high carbon content. Welding this outside face with hard surfacing electrodes to produce resistance to penetration is not so difficult, but it has little ductility and therefore, little value for shock resistance.

Our laboratory finally developed what we know as masking. The plate edges that are to be welded are sprayed with a copper coating which prevents those surfaces from absorbing more carbon in the carburizing process. The welder is now no longer confronted with a bimetal, but can proceed using practically the same technique employed in the welding of homogeneous armor. We like to think of the result in the terms of a homogeneous plate to which has been added over a considerable portion, a hard surface which increases its resistance to small arms fire, but which in no way interferes with the welding process.

The original hull of riveted design was a rectangular box with vertical sides of heavy face-hardened armor plates. The front and back plates sloped below the sponsons. The probability of enemy fire against an armored hull is greatest against the front, hence the armor of this hull is sloped upward above the front main drive housing to sponson height.

The sponsons are the rectangular space projected over the wheel track on each side. The horizontal top armor projecting both sides over the sponsons.

Fig. 7—The 13-Ton Welded Light Combat Tank Under Production at A.C.F. During the Past Year

The most desirable joints are angle butt in which the plate edges are placed tightly butting together. The arrangement of plates is such that hits from the side, front and rear do not fall on unsupported plates, or with few exceptions, on plates supported by butt straps inside. Butt straps provide extra thickness against penetration.

The riveted butt-strap construction requires the drilling by template of over 2300 holes, fitting of plates and buttstrap angles, finally reaming of holes to provide proper rivet bearing and the driving of many hundred rivets with many countersunk.

This system permits subassemblies and large daily production through moving track line assembly.

According to the newspaper reference, the rivet heads thrown inside the tank from a projectile impact created a hazard to the operators which led to the lining of riveted tanks.

The chief weakness of the riveted joint was the low shock resistance.

Research, primarily through H-plate investigations and some cross sections, some months later, brought about a hull with welded joints with some revisions in design. The welded joint, from the best information has eliminated the above deficiencies.

The schedule of tank production in the past several months has called for higher and higher production. This alone created many problems as to space and equipment in repeated expansions in order to connect up with the scheduling. At this time, the pressure on our tank delivery schedule would not permit the loss of a single unit.

The transition from the riveted hull to the hull of welded construction again required space and different equipment such as special welding jigs, welding positioners, hand welding machines and automatic plug welders. Plug welding was substituted for all horizontal riveted attached butt-strap angles which eliminated exposed rivet heads. A plug welding setup produced welds in a few seconds at 800 amp., through the use of push button electronic controlled welding heads, operating on ball bearing carriages. This operation required attention by the operator but with little fatigue.

The design of the welded hull permitted the transition program to be executed in three steps which with so large a daily output, was most desirable.

Step one specified: (*a*) all sponson connection angles to be plug welded to sides; (*b*) top and bottom plate of the sponson to be riveted in the final assembly; (*c*) front "T" section to be welded to the side; (*d*) all hinges to be welded to door and door frame; (*e*) the rear top angles which take the top plate to be plug welded to the sides up to the curved rear hood. Accumulation of these welded subassemblies for several weeks permitted the substitution overnight without loss of production.

The second step included: (*a*) rear hood to be formed and angles plug welded to the side. The formed armor plate was slightly modified in design to facilitate welding assemblies; (*b*) the entire front cover plate which protects the bow gunner and driver changed to welded construction; (*c*) the bottom sponson plate was flanged and plug welded to the inside of the side plate. The transition on step two was made without loss of production.

Changeover to a complete welded hull in the final step included the entire sides of the welded hull, which meant: (*a*) the plug welding of the bottom side angles; (*b*) the side rear angles to the side; (*c*) bulkhead angles and (*d*) gasoline tank pocket; (*e*) the butt welding of the 2 side sections together eliminating the butt straps; (*f*) the 2 vertical seams on the sponson were changed from plug butt strap to full butt weld.

For production reasons in the final assembly, the top plate and the bottom or floor sheet are riveted to the connection angles; these are vertical rivets.

Through several weeks of planning, purchase and rearrangement of machines and equipment, the transition to this welded design was accomplished in the midst of a very large daily production without interruption or loss of production. In fact, in one case, production was actually increased 3 tanks a day.

Application of arc welding to turret and hull assembly has been presented in all its detail. Resistance spot welding of satisfactory ductility has replaced many exposed rivet heads in light sheet metal assemblies, such as sand guards, boxes and brackets required on the same combat tank. Eleven spot-welding machine days were required for normal output.

What as to the result, of transition from riveted to welded light combat tank, 1943 Model?

A light-welded combat tank with more protection to the personnel in the tank of our armed forces:

(*a*) As it is more heavily armored in front.
(*b*) A 20° sloping sponsons, this being equivalent ballistically to an additional $^1/_8$ in. thickness of armor plate.
(*c*) Flat all-welded turret "built right" ballistically.
(*d*) A welded tank of lighter weight which gives greater horsepower per pound of weight extending cruising range.
(*e*) A light-welded combat tank better streamlined.

These are the results through close collaboration of all sections of the Army Ordnance Department tank division and our company.

We have reason to believe that our Government is well satisfied with the job we have done and are still doing—both as to quantity and quality.

Messrs. Amble, Ensign and Steinmeyer, of our Berwick plant, have made valuable suggestions to the authors.

Modern Welding Methods for Copper and Copper Alloys*

By J. J. Vreeland

Introduction

THE welding of copper and copper alloys has shown considerable advancement due to the willingness of fabricators to consider the use of methods that prove faster and more economical than the oxyacetylene brazing method. The increased application of the carbon arc method using a silicon-bronze filler rod has been the result. Even though other filler rods have proved suitable, they have not proved the equal of silicon bronze for general usage.

This paper is to deal predominantly with the welding (fusion) of copper and its alloys and should not be confused with the brazing of these alloys. Brazing as defined in the *Welding Handbook* is a group of metal-joining processes wherein the filler metal is a non-ferrous metal or alloy whose melting point is higher than 1000° F., but is lower than that of the metals or alloys being joined. It must also be pointed out at this time, that "bronze welding" as previously used in industry, is a brazing process using brass brazing rods, such as naval brass, low fuming bronze and manganese bronze. The term bronze welding as used in this paper will refer to the welding of bronzes using a bronze welding rod.

The choice of welding method and welding rod has become of prime importance to obtain the results at a minimum cost. The welding method selection would naturally depend on the material being welded as to alloy and gage. Thin gage metal, in most cases, cannot be properly welded using the carbon arc method because of the inability to weld without burning through. Oxyacetylene welding would be the choice because of lower heat and more control of weld metal. Shape of the unit being fabricated would also be a factor. More warpage can be expected on shapes other than tubular, and since the oxyacetylene method causes more warpage, the carbon arc would take preference. Welding overhead on some materials is quite impossible with the carbon arc, resulting in the choice of the oxyacetylene method. The choice of welding rod is governed by the choice of welding method and to the type of service the finished unit is subjected to. Consideration should be given as to the amount of cold working the welded joint may be subjected to after completion. Corrosion resistance of the weld should be considered when the finished unit is expected to operate under corrosive conditions. These points are brought out to show the necessity of a little thought beforehand for the proper choice of welding method and welding rod for maximum economy in production and maximum life in service.

In all welding, best results are only possible when certain precautions are taken. Removal of dirt, grease and oxides must be effective from the edges of base metal to be joined and from the welding rod. Proper flux should be used and the resulting slag formed from each welding bead must be removed to obtain maximum density in joints requiring multiple bead welding.

Proper jigging and technique of welding are also factors governing results. Excessive movement of metal during a welding operation may result in considerable trouble due to cracking and off measurements. Tack welding every 6 to 8 in. with welds should be done in carbon arc welding, to minimize the movement of the base metal. In oxyacetylene welding, proper allowance in the setup of the welding joint must be made for the expansion or movement of metal during the preheating and welding periods. Quite often in oxyacetylene welding auxiliary torches should be used to bring the metal up to welding heat and to continue to supply heat to the base metal to permit ease of welding.

In carbon arc welding, it is permissible for the operator to stop welding at any time. It is quite important, however, that when welding is resumed, the arc should be struck at a point approximately 1 in. back from the start. No filler rod is added until the arc is brought up to the point where the stop occurred. If some metals require slight preheat for successful carbon arc welding, it is advisable to preheat slightly after a stop which is long enough to allow the metal to cool to room temperatures, before starting the weld. In oxyacetylene welding it is not advisable to stop the welding for any period which permits too much loss of heat in the base metal. If such stops in welding are necessary, it is recommended that preheating torches be used to maintain the necessary heat to insure satisfactory results when welding is resumed.

Welding of Tough Pitch Copper

Oxyacetylene welding of copper has been used for many years using tough pitch copper, deoxidized copper and silver bearing copper welding rods. The results obtained were fairly satisfactory but hot working and cold working of the weld was a requisite for good physical properties and density. The type of copper used (tough pitch) does not lend itself very well for welding methods and this type of copper is responsible for the results obtained.

Tough pitch copper, containing a small percentage of oxygen in the form of copper-cuprous oxide eutectic, should not be welded using the oxyacetylene method. When tough pitch copper is heated up to approximately 1680° F. and higher, accumulations of the copper-cuprous oxide eutectic will occur in the grain boundaries. The extent of this segregation depends upon both the time the copper is held at this elevated temperature and upon the temperature itself. Considerable segregation will occur when the copper is actually melted. The segregation of

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† Metallurgical Engineer, Sales Promotion Division, Chase Brass & Copper Co.

Table 1—Carbon Arc Welding Electrolytic Copper

Thickness Base Metal, In.	Miter	Root Aper., In.	Filler Rod Type	Filler Rod Size, In.	Carbon Diam. In.	Closed Circuit Amp.	Closed Circuit Volts	Tensile Strength, Psi.	Free Bend, %
1/16	None	3/32	Low-tin	1/8	1/4	140–150	30–35	29,800	..
1/8	None	3/32	Low-tin	3/16	5/16	180–200	35–40	27,450	..
3/16	45°	1/16	Low-tin	5/16	3/8	280–300	40–45	27,600	45
1/4	45°	1/8	Low-tin	3/8	1/2	540	55	26,100	32
1/4	45°	1/8	Low-tin	3/8	1/2	540	55	30,400	28*
3/8	45°	3/32	Low-tin	1/2	1/2	No results		...	..
1/16	None	3/32	High-tin	1/8	1/4	160	35	27,500	..
1/8	None	3/32	High-tin	3/16	5/16	220–240	35–40	28,400	..
3/16	45°	1/16	High-tin	5/16	3/8	300–320	45–50	30,400	21.5
1/4	45°	1/8	High-tin	3/8	1/2	520	55	30,600	31
3/8	45°	3/32	High-tin	1/2	1/2	520–560	55	27,500	18
1/16	..	3/32	Silicon-bronze	1/8	1/4	130–140	25–30	12,250	..
1/8	..	3/32	Silicon-bronze	3/16	5/16	210	35	17,100	..
3/16	45°	1/16	Silicon-bronze	5/16	3/8	280–300	40–45	21,200	18
1/4	45°	1/8	Silicon-bronze	3/8	1/2	560	50	15,800	3.5
3/8†	45°	3/32	Silicon-bronze	1/4	1/2	400	35–40		
				1/4	1/2	400	35–40	15,200	3.0
				5/16	1/2	400	35–40		

* Weld peened and annealed.
† Multiple bead welding.

the copper-cuprous oxide will, at least, partially explain the inferior results obtained in attempting to weld the heavier gages of tough pitch copper using the oxyacetylene method. Thinner gage copper can be welded more successfully because of the minimum length of time the copper is above the temperature at which segregation of the copper-cuprous oxide eutectic occurs. Brazing operations are performed at temperatures below or very slightly above this critical temperature and no apparent segregation occurs.

Carbon arc welding of gages of tough pitch copper heavier than 1/16 in. has shown no tendency for copper-cuprous oxide segregations. This is due to the ability of the operator to weld with high heats and high lineal speeds, minimizing the time that any of the copper is above the critical temperature. Because of the high reducing atmosphere, the copper-cuprous oxide eutectic adjacent to the weld, is susceptible to reduction, causing slight embrittlement. It has been found that regardless of the type welding rod used, the ductility of the copper adjacent to the weld is quite erratic, indicating various degrees of embrittlement. The degree of embrittlement is controlled largely by speed of welding and, therefore, a greater tendency for embrittlement in the heavier gages of the copper being joined can be expected.

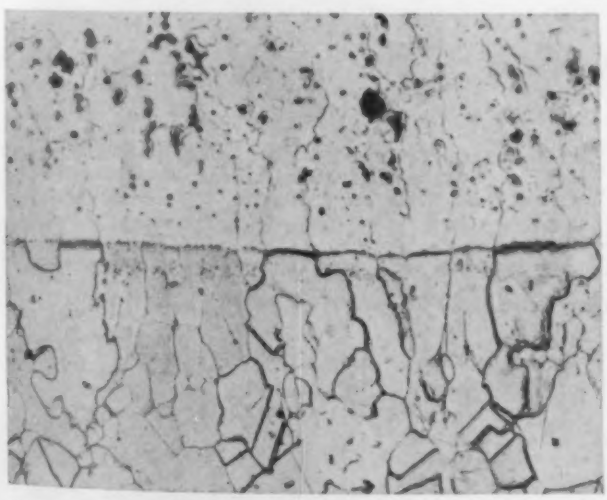


Fig. 1—Carbon Arc Weld of Tough Pitch Copper Using High Tin Phosphor Bronze Welding Rod. Note the Intergranular Bond and Porosity in Weld Metal. Dark Spots Are Copper-Cuprous Oxide Eutectic in Base Metal. Strength of Joint, 27,500 Psi. Mag. 50 ×. Etchant–H_2O_2 + NH_4OH

Phosphor-bronze type welding rods are recommended for the carbon arc welding of tough pitch copper. The low-tin (1½% tin) or the high-tin (8–10% tin) rods have the high fluidity and the ability to withstand the high heat of welding. Both welding rod compositions contain residual phosphorus (app. 0.3%) which is added as a self-fluxing agent. Satisfactory results are obtained as shown in Table 1. It is not advisable to weld thicknesses of copper heavier than 3/8 in., using this type welding rod, since multiple bead welding has not proved successful, due to the hot shortness of the deposited weld metal. The low-tin phosphor bronze is capable of withstanding cold working after deposition, and should be used for fabrication if any cold working is to be done after welding. The high-tin phosphor bronze weld metal is hard and brittle and will withstand only moderate cold working. Both rods handle equally well under the arc with the high-tin rod taking preference, for the welding of heavier gages. Figure 1 illustrates the structure obtained with a carbon arc weld of tough pitch copper using a high-tin phosphor bronze rod. Silicon-bronze rod should not be used for the welding of tough pitch copper. Lineal welding speeds are reduced about 40% as compared with the welding speed using phosphor-bronze welding rods, because of the lower fluidity. The slower welding speeds are responsible for a wider zone of reduction of the copper-cuprous oxide eutectic, yielding low tensile and free bend values. This is indicated in Table 1, and Fig. 2 illustrates the greater amount of reduction adjacent to the weld metal.

The use of deoxidized copper for welding work eliminates faulty results attributable to the base metal. In deoxidized copper in which no copper-cuprous oxide eutectic occurs, there can be neither segregation, nor reduction of the copper-cuprous oxide eutectic adjacent to the weld. The success of this welding depends upon the choice of welding rod, capacity of heat available and welding technique.

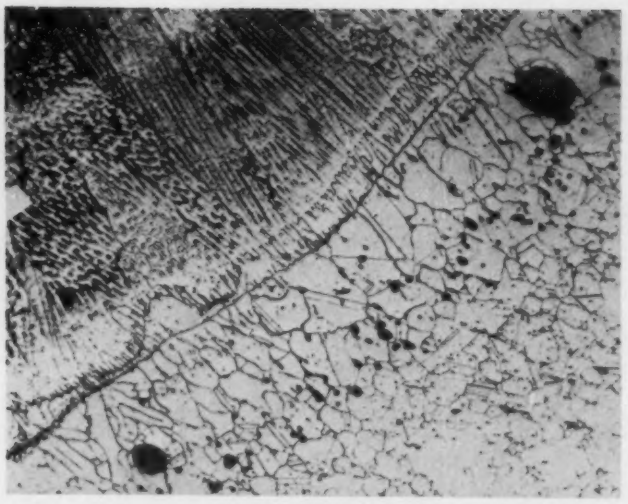


Fig. 2—Carbon Arc Weld of Tough Pitch Copper Using High Silicon Bronze Welding Rod. Note the Large Holes in Base Metal Due to Reduction of Copper-Cuprous Oxide Eutectic. Strength of Joint, 18,000 Psi. Mag. 75 ×. Etchant—H_2O_2 + NH_4OH

Oxyacetylene Welding Deoxidized Copper

Oxyacetylene welding of deoxidized copper has been used for a number of years and the results obtained have been directly responsible to the welding rod used. Tough pitch copper welding rods tend toward a highly porous weld, with tensile strengths (non-reinforced) running approximately 18,000 psi. The rod handles satisfactorily while using a flux designed for copper welding. Phosphorus deoxidized and silver bearing deoxidized copper welding rods give dense deposited weld metal with tensile values approximately 25,000 psi. The main objection to the phosphorous deoxidized copper rods is the high fluidity of the weld metal, making them hard to handle for welding in all positions. For thicknesses of copper under 3/16 in. being welded in the horizontal position, the results obtained are satisfactory. The high fluidity of these rods tends to permit faster lineal welding speed; and for thicknesses over 3/16 in. this high fluidity increases the likelihood of a brazed joint instead of a weld. The resulting tensile strengths (non-reinforced) are much less than 25,000 psi. Because of this high fluidity, extreme difficulty is encountered when attempting vertical-horizontal and overhead welds. When attempting these types of welds, the highly fluid weld metal tends to run out of the joint.

The use of a silicon copper welding rod containing approximately 0.15 to 0.3% silicon produces exceptional results as to tensile strength and ease of welding in all positions. Sound weld deposits are obtained and the small amount of silicon present lowers the apparent fluidity so that a smaller pool of weld metal is obtained during the welding process. Positive fusion is more certain because of the lesser tendency of the weld metal to run much ahead of the welding flame. The same sluggishness of weld metal makes vertical-horizontal and overhead welding easier, assuring the operator of obtaining satisfactory fusion and physical properties. To insure maximum density and freedom from slag pockets, a satisfactory copper welding flux should be used. Figures 3 and 4 illustrate the typical structure obtained for oxyacetylene weld of deoxidized copper using a silicon-copper welding rod.

Table 2 shows the results obtained when forehand welding is used on various thicknesses of deoxidized copper. To shorten preheating and welding time, an

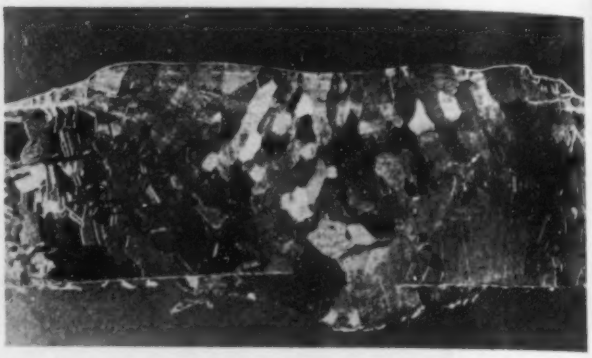


Fig. 3—Oxyacetylene Weld on 3/8-In. Deoxidized Copper Using Silicon Copper Welding Rod. Strength of Joint, 30,000 Psi. Mag. 2 ×. Etchant—Chromic Acid

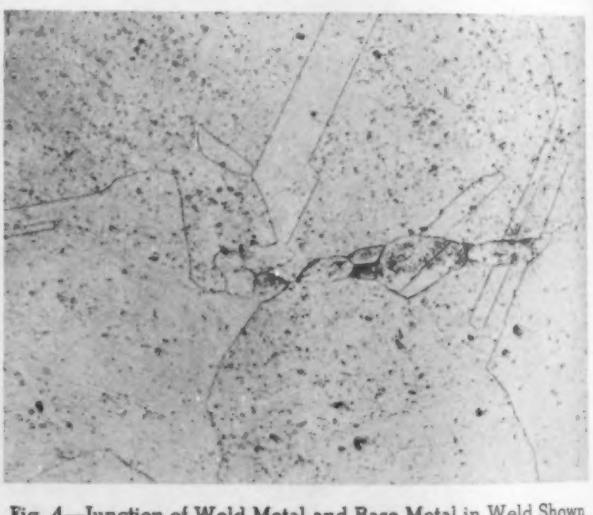


Fig. 4—Junction of Weld Metal and Base Metal in Weld Shown in Fig. 3. Note the Intergranular Bond and Equiaxed Structure of Weld Metal. Mag. 50 ×. Etchant—Chromic Acid

Table 2—Oxyacetylene Welding Deoxidized Copper

Gage Base Metal, In.	Miter	Torch Tip No.	Filler Rod Type	Filler Rod Size, In.	Tensile Strength, Psi.	Free Bend, %
1/8	..	10	Silicon-copper	1/8	29,800	..
3/16	45°	12	Silicon-copper	5/32	26,800	50
1/4	45°	12 Weld. 10 Aux.	Silicon-copper	3/16	28,100	46
3/8	45°	14 Weld. 12 Aux.	Silicon-copper	1/4	30,000	56
1/2	45°	15 Weld. 12 Aux.	Silicon-copper	1/4	27,500	51

NOTE: No. 10 tip used on preheating torch for 1/8- and 3/16-in. copper.

Table 3—Oxyacetylene Welding Copper Tube and Pipe

Nominal Size and Type	Miter	Torch Tip No.	Type of Weld	Filler Rod Type	Filler Rod Size, In.	Tensile Strength, Psi.
2-in. S.P.S. (0.250 wall)	45°	10	Rolling	Silicon-copper	5/32	28,500
6-in. Type L (0.140 wall)	..	10	Rolling	Silicon-copper	5/32	31,900
6-in. Type L	..	10	Vertical-horizontal	Silicon-copper	5/32	28,600
6-in. Type L	..	10	Stationary	Silicon-copper	5/32	30,700

NOTE: No. 10 tip used on preheating torch for 6-in. Type L water tube.

Table 4—Carbon Arc Welding Deoxidized Copper

Thickness Base Metal, In.	Miter	Root Aper., In.	Filler Rod Type	Filler Rod Size, In.	Carbon Diam., In.	Closed Circuit Amp.	Closed Circuit Volts	Tensile Strength, Psi.	Free Bend, %
1/16	None	3/32	Silicon-bronze	1/8	1/4	120–140	20	32,700	..
1/8	None	3/32	Silicon-bronze	5/16	5/16	220–230	35	31,600	..
3/16	45°	1/16	Silicon-bronze	5/16	3/8	300	40	30,500	38.5
1/4	45°	1/8	Silicon-bronze	3/8	1/2	560	50	30,750	41
3/8*	45°	3/32	Silicon-bronze	1/4	1/2	400	35–40	32,300	43
				1/4	1/2	420	35–40		
				5/16	1/2	420–440	35–40		
1/2*	45°	3/32	Silicon-bronze	1/4	3/8	350	35	31,650	48
			Silicon-bronze	5/16	1/2	540	35		
			Silicon-bronze	3/8	1/2	540	40		
3/4*	37 1/2°	3/32	Silicon-bronze	5/32	3/8	340–360	33–35	30,450	37.6
			Silicon-bronze	1/4	1/2	400–440	35–40		
			Silicon-bronze	5/16	1/2	460–480	35–40		
			Silicon-bronze†	3/8	1/2	440–480	35–40	...	...
			Silicon-bronze‡	5/16	1/2	440–480	35–40	...	...
1/16	45°	1/16	Low-tin	5/16	3/8	300	40	28,000	...
1/4	45°	1/8	Low-tin	3/8	1/2	520	55	29,800	...
1/4†	45°	1/8	Low-tin	3/8	1/2	520	55	31,000	...

* Multiple bead welding. Plates preheated.
† Weld peened and annealed.
‡ Parallel beads used to minimize heat effect on base metal.

auxiliary torch was used as indicated. The ductility of the joint is exceptionally good, permitting in most cases free bends of 180°. Table 3 indicates the results obtained for copper pipe and tube welding. Results on the 6-in. Type L water tube are interesting in that satisfactory tensile strengths are obtained in any position of welding.

Using the oxyacetylene method of welding using the silicon-copper welding rod, no backup bar or chill strip is required. With the proper precaution and correct welding rod size, satisfactory penetration can be obtained. Because of this result and the comparative ease of welding in all positions, this method of welding pipe and tube is recommended over the other methods.

Oxyacetylene brazing of either type of copper can be very easily done using the conventional yellow brass brazing rods such as naval brass, manganese bronze, low fuming bronze and Muntz metal. Results obtained depend on the type of flux used and the skill of the operator.

Carbon Arc Welding Deoxidized Copper

Successful carbon arc welding of deoxidized copper depends upon the choice of welding rod and the capacity of heat available. It must be remembered that because of the high thermal conductivity of copper, high amperages and voltages are required to compensate for the rate of heat dissipation.

In Table 4 are shown the approximate values of amperages and voltages. It is noted that for sufficient flexibility in range of thicknesses, a 600-amp. machine should be used, capable of holding an arc drawing at least 50 v. while welding. It is acceptable practice on gages 1/4 in. and heavier to preheat the copper slightly to insure more sound weld metal and to lower the starting heat requirements.

The choice of welding rod is based on the ability to produce sound weld metal at the temperatures required. The resulting ductility of the deposited weld metal is also of importance. Through extensive investigations it has been proved that the silicon-bronze type rod containing approximately 3% silicon is a superior rod for the carbon arc welding method. The weld metal is not extremely fluid under the arc, as is the case with phosphor-bronze rods. Welding speeds must then be slower to insure satisfactory density of weld metal. To obtain maximum density of weld metal, a flux designed to slag off silicon oxide must be used.

Phosphor-bronze Grade D welding rod has been used quite successfully for the carbon arc welding of deoxidized copper. Since multiple bead welding is not recommended using this type rod, the thickness of copper is limited to 3/8 in., similar to the recommendation given for the carbon arc welding of tough pitch copper. The ductility of the weld metal is not sufficient to allow much cold working or forming after welding. The high fluidity of the weld metal on heavier gages of copper has a tendency to cause cold laps. To minimize this, the work should be tilted to an angle of 7 to 15° to permit welding slightly uphill to prevent the weld metal from flowing ahead of the arc.

All carbon arc welding of copper should be done in a downhand position, and the joint should be backed up with a copper chill bar or strip. If a bar is to be used and removed after welding, the thickness should not be

Fig. 5—Carbon Arc Weld of Deoxidized Copper Using High Silicon Bronze Welding Rod. Strength of Joint, 32,300 Psi. Mag. 1.5 ×. Etchant—Chromic Acid

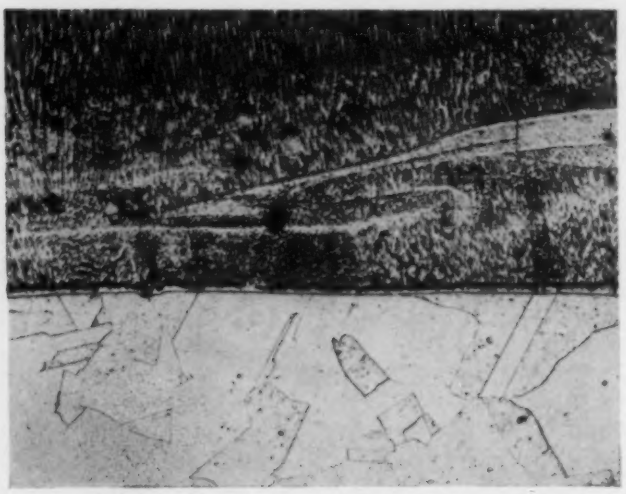


Fig. 6—Junction of Weld Metal and Base Metal of Weld in Fig. 5. Note Structure of Weld Metal and Intergranular Bond at the Junction. Mag. 50 ×. Etchant—Chromic Acid

less than $^3/_8$ in. It is recommended that a groove approximately $^1/_4$ in. wide, $^1/_{32}$ in. deep, be machined in the bar to aid in obtaining proper penetration. Often a chill strip, approximately $^1/_8$ in. thick, could be used and left as a reinforcement on the underside of the weld.

Figures 5, 6 and 7 are carbon arc welds of deoxidized copper using the silicon-bronze weld. It is not recommended that the carbon arc method be used for copper pipe welding unless a chill strip is used and all welds are rolling welds. Due to the necessity of high heats, burning through would result if no chill strip were used. It is very difficult to weld by this method in a vertical or overhead position.

Figure 8 is an installation of square tubular bus, preassembled by carbon arc welding using low-tin phosphor-bronze rod. Figure 9 illustrates the application of carbon arc welding of deoxidized copper using the high-silicon-bronze rod for pressure vessels. Figure 10 shows parts of an alcohol and ether processing plant. The deoxidized copper welded with the high-silicon-bronze rod, underwent considerable cold-forming operations. The welded joints took the cold-forming operations without signs of fracturing.

Welding of High-Copper-Zinc Alloys

The welding of this group of copper-zinc alloys is best illustrated by the methods giving best results in the welding of red brass (85% Cu, 15% Zn).

Considerable joining of red brass has been done in the past and described under the term "bronze welding." This method, previously mentioned is a very satisfactory method of joining, using the popular yellow brass brazing rods. Figures 11 and 12 show a typical brazed joint on red brass. Tensile properties of this type joint is very satisfactory but the root-bend values are inconsistent. The sharp lines of demarcation between base metal and filler metal indicate a plane of weakness, which plainly shows up on a root-bend test.

Red brass standard pipe has replaced yellow brass standard pipe to combat corrosion failures occurring under certain unfavorable conditions. Yellow brass is subject to dezincification failures under such conditions; the same type of failure is possible when red brass pipe is joined by "bronze welding," but the failure in this case takes place at the joint. To overcome this type of failure, a welding rod containing a high percentage of copper with good welding qualities for oxyacetylene welding has been developed. The rod, a low silicon bronze, contains 1.5% silicon, 1.00% zinc and the balance copper.

The handling property of the rod under the torch is very satisfactory, since the weld metal is not so fluid, which property increases the tendency to braze. By maintaining a smaller pool of weld metal under the torch, closer control is obtained, resulting in more assurance of fusion to the side walls.

In the oxyacetylene welding of red brass pipe or plate in thickness from $^1/_8$ to $^3/_8$ in., inclusive, the edges to be joined must be beveled to a 45° single miter. Over $^3/_8$ in. in thickness best results are obtained by reducing the miter to $37^1/_2$°, or a 75° included angle. A flux specially designed for silicon-bronze gas welding should be used, in the conventional manner, for best results. It is also suggested that the flux, mixed with alcohol to a thin paste, be applied with a brush to both the work and welding rods. It is also recommended that for all gages $^1/_4$ in. and heavier, either a preheating torch or auxiliary torch be used.

Table 5 shows some typical results obtained by the oxyacetylene welding of red brass pipe and plate. Figures 13 and 14 are gas welds on $^1/_2$-in red brass plate using the low-silicon-bronze rod.

Carbon arc welding of red brass is recommended and satisfactory results are obtained particularly when the welding is done in a downhand position. The welding rod for best results is the high-silicon-bronze rod containing essentially 97% copper and 3% silicon. High-tin phosphor-bronze welding rod could be used with satisfac-

Fig. 7—Carbon Arc Weld on $^3/_4$-In. Deoxidized Copper Using High Silicon Bronze Welding Rod. Strength of Joint, 32,400 Psi. Mag. 2 ×. Etchant—Chromic Acid

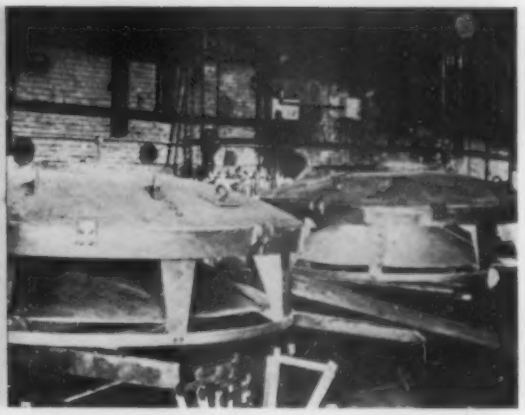


Fig. 8—Square Tubular Bus Installation Preassembled with Carbon Arc Welding Using Low Tin Phosphor Bronze Welding Rod

Fig. 9—Deoxidized Copper Pressure Vessel Carbon Arc Welded Using High Silicon Bronze Welding Rod

Fig. 10—Deoxidized Copper Carbon Arc Welded Using High Silicon Bronze Welding Rod and Cold Formed for Alcohol and Ether Processing Plant

tory results, but due to the inability to cold work the joint would limit its use. Also, because of the need of multiple bead welding for heavier gages, would give preference to the silicon bronze.

Table 6 shows the results obtained in the carbon arc welding, multiple beads of 1/2-in. thick red brass plate. Suggested procedure is given for other gages in this table. Slight preheating of all thicknesses heavier than 3/16 in. is recommended for best results.

All gages of red brass 3/16 to 1/2 in., inclusive, should be beveled to a 45° single miter, and welded using multiple beads. For gages 1/2 to 3/4 in., inclusive, it is recommended that a 37 1/2° single miter be used. For gages over 3/4 in. 45° double miter is suggested. A grooved backup bar should be used on thicknesses under 3/16 in. Regular silicon-bronze carbon arc-welding flux should be used and applied as a thin alcoholic paste to the work and welding rods.

Table 5—Oxyacetylene Welding Red Brass

Form	Thickness, In.	Type Weld	Miter	Torch Tip No.	Filler Rod Type	Filler Rod Size, In.	Tensile Strength, Psi.	Free Bend, %
2-in. S.P.S. pipe	3/16	Rolling	45°	9	Low-silicon-bronze	5/32	38,200 *R*	..
6-in. S.P.S. pipe	1/4	Rolling	45°	12	Low-silicon-bronze	3/16	37,700 *R*	..
							35,300	..
		Stationary	45°	10	Low-silicon-bronze	3/16	37,300 *R*	..
							35,500	..
		Vertical-horizontal	45°	10	Low-silicon-bronze	3/16	37,200 *R*	..
							35,200	..
4-in. extra heavy pipe	0.341	Stationary	45°	10 Weld.	Low-silicon-bronze	3/16	36,900 *R*	..
				10 Aux.			36,000	..
Plate	1/2	Forehand	37 1/2°	12 Weld.	Low-silicon-bronze	1/4	37,000 *R*	61
				10 Aux.			34,000	..

NOTE: No. 10 tip used on preheating torch for 6-in. S.P.S. pipe.
Tensile strength 1/2-in. red brass plate material, 44,000 psi.
R—Indicates reinforced weld.

Table 6—Carbon Arc Welding Red Brass

Thickness Base Metal, In.	Miter	Root Aper., In.	Filler Rod Type	Filler Rod Size, In.	Carbon Diam., In.	Closed Circuit Amp.	Closed Circuit Volts	Tensile Strength, Psi.	Free Bend, %
1/8	..	3/32	High-silicon-bronze	3/16	5/16	180–220	30–35	...	..
5/16	45°	1/16	High-silicon-bronze	5/32	1/4	150–190	25–30	...	..
				3/16	5/16	180–220	30–35	...	..
1/4	45°	1/16	High-silicon-bronze	3/16	5/16	170–210	30–35	...	..
				1/4	3/8	200–260	30–35	...	..
3/8	45°	3/32	High-silicon-bronze	3/16	3/8	180–220	28–30	...	..
				1/4	3/8	200–260	30–35	...	..
				1/4	1/2	240–300	30–35	...	..
1/2	45°	3/32	High-silicon-bronze	3/16	3/8	200–220	28–30		
				1/4	3/8	240–260	30–33	41,700 *R*	65
				1/4	1/2	300–320	33–35	37,650	..
				5/16*	1/2	300–320	33–35	...	..
				1/4	1/2	320–340	33–35	...	..

* Parallel beads used to minimize heat effect on base metal.
Tensile strength of 1/2-in. red brass base metal, 44,000 psi.
R—Indicates reinforced weld.

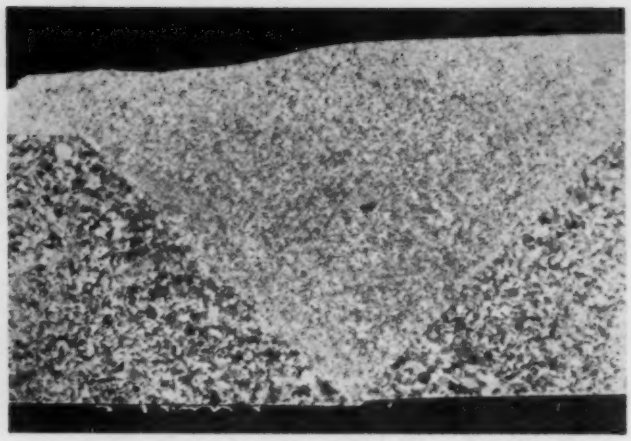


Fig. 11—A True Braze or "Bronze-Weld" on 1/2-In. Red Brass Plate. Note the Sharp Line Between Brazing Material and Base Metal. Strength of Joint, 30,000 Psi. Mag. 3 ×. Etchant—H_2O_2 + NH_4OH

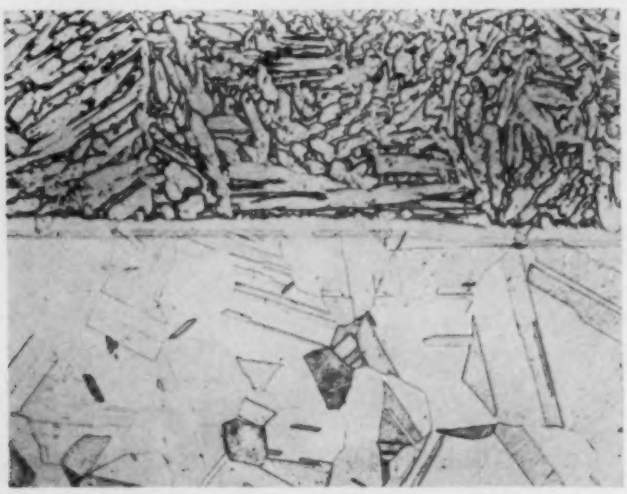


Fig. 12—Junction of "Bronze-Weld" Shown in Fig. 11. Mag. 50 ×. Etchant—H_2O_2 + NH_4OH

Figures 15 and 16 show a carbon arc weld of 1/2-in. red brass plate using the high-silicon-bronze rod.

Figures 17 and 18 illustrate the welding installation of red brass piping using the oxyacetylene welding method and low-silicon-bronze rod. The installation required overhead and vertical horizontal welding, which was easily done. The installation involving 250,000 lb. of piping, diameters from 4 to 14 in., was satisfactorily completed. There was a minimum amount of trouble and leakers when tested.

Welding of Low-Copper-Zinc Alloys (Copper Content 58 to 80%)

The welding of this group of copper-zinc alloys is essentially the same as that found successful for Muntz metal and naval brass.

Muntz metal (60% Cu, 40% Zn) and naval brass (59% Cu, 1/4% Sn, balance Zn.) are more commercially used where welding fabrication could be successfully used. These alloys have been extensively brazed using the silver alloy and phos-copper type brazing materials, and oxyacetylene welded using the popular yellow brass brazing rods. For the welding application, the filler rods used can rightfully be termed yellow brass welding rods and the operation termed brass welding.

In the oxyacetylene welding of these alloys using yellow brass rods (naval brass, manganese bronze, low fuming bronze), care must be taken by the operator to obtain actual fusion of the side walls of the base metal. The rods mentioned are not designed for welding applications because of the high fluidity of the filler metal, and if particular care is not given, a brazed joint is most likely to be obtained. A welded joint is superior to a brazed joint in ductility, particularly when root-bend values are compared. There is definitely need for an alloy brass welding rod with lower fluidity than the present brass brazing rods for the welding of low-copper-zinc alloys. Such a development would definitely be an aid to chemical equipment fabricators and industrial piping concerns.

The carbon arc welding of Muntz metal and naval brass is a recent development and is being used in the fabricating of distilling units and large diameter piping. The success of this welding completes the list of important commercial copper alloys to be commercially welded by the carbon arc method.

The welding rod used can be either low fuming bronze rod or high-silicon-bronze rod. The high-silicon-bronze rod should definitely take preference because of the greater ease of handling during welding and the greater ductility resulting in the weld. In the arc welding of low-copper-zinc alloys, there will be a considerable evolution of zinc, but with the use of the high-silicon-bronze rod there is 75% less zinc evolution to contend with. The

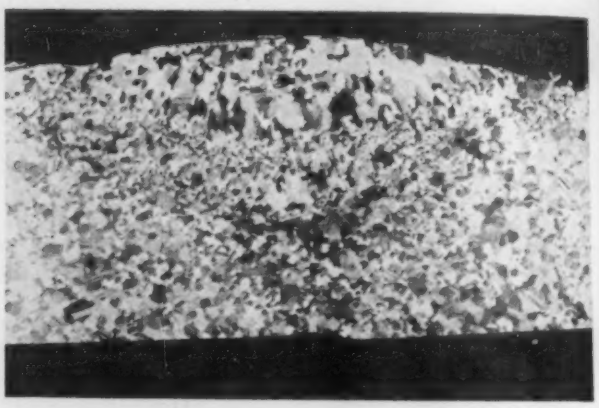


Fig. 13—Typical Oxyacetylene Weld on 1/2-In. Red Brass Plate Using Low-Silicon Bronze Welding Rod. Strength of Joint, 37,000 Psi. Note the Uniformity of Grain Structure and the Intergranular Bond Indicating Fusion of Weld Metal and Base Metal. Mag. 2 ×. Etchant—Chromic Acid

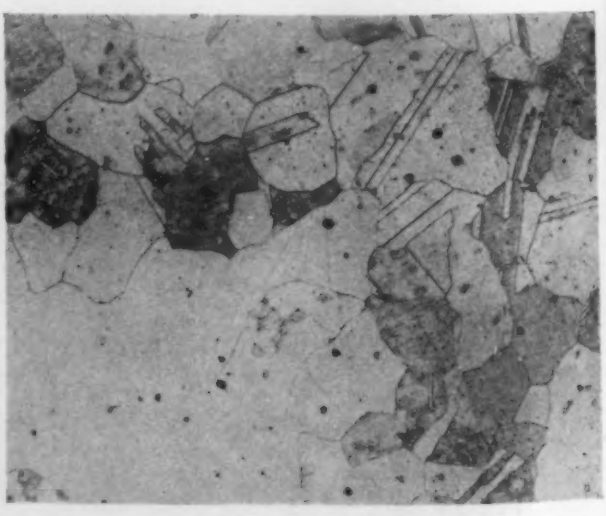


Fig. 14—Junction of Weld Metal and Base Metal Showing Perfect Intergranular Bond, as Shown in Fig. 13. Mag. 50 ×

evolution of zinc is distinguished by the clouds of zinc oxide fumes around the welding operation. If these fumes are not removed by a suction pipe, they will interfere with the operator's vision as well as being injurious to his health. Using the high-silicon-bronze welding rod and being properly equipped to remove the zinc oxide fumes, excellent results can be expected at all times. Figure 19 illustrates the structure of Muntz metal welded using low fuming bronze rod and Fig. 20 illustrates the more ductile weld structure using high-silicon-bronze rod.

Preheating of the base metal is essential to obtain proper fusion and sound deposited weld metal. All gages of metal thicker than $^1/_8$ in. should be beveled to a 45° angle to minimize disturbance of the base metal. Multiple bead welding is recommended for welding thicknesses $^3/_{16}$ in. and heavier. Particular care should be taken to chip out all crater cracks that occur at all stops in the welding, particularly if low fuming bronze rod is being used. Flux should be used in the same manner as recommended for silicon-bronze welding, i.e., thin paste with alcohol painted on the cold work before preheating and dry flux sprinkled on lightly after the work is hot. If low fuming bronze rod is used, the flux should be a good brazing flux but silicon-bronze flux should be used with the high-silicon-bronze welding rod.

Figures 21 and 22 illustrate a setup for welding fabrication of $^3/_{16}$-in. thick Muntz metal into 14-in. diameter piping by the carbon arc method of welding. Preheating of the Muntz metal was accomplished by using a gasoline torch on the inside of the steel pipe backing on which the welding was performed. Figure 23 illustrates the welded tube. For girth welds, a removable backup or chill strip is recommended to insure maximum weld metal density and for ease of welding.

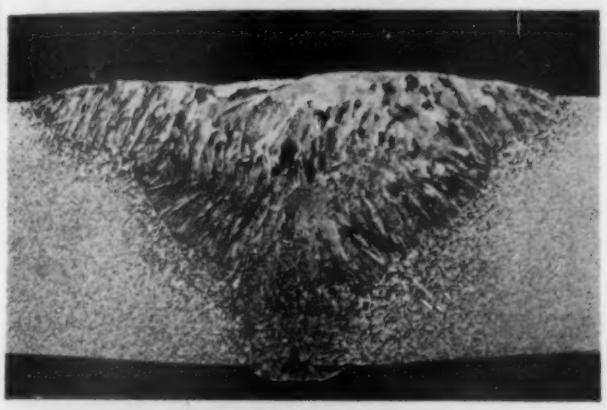


Fig. 15—$^1/_2$-In. Red Brass Plate Carbon Arc Welded Using High Silicon Bronze Welding Rod. Note the Small Effect of the Welding on the Base Metal. Strength of Weld, 41,700 Psi. Mag. 2.5 × Etchant—Chromic Acid

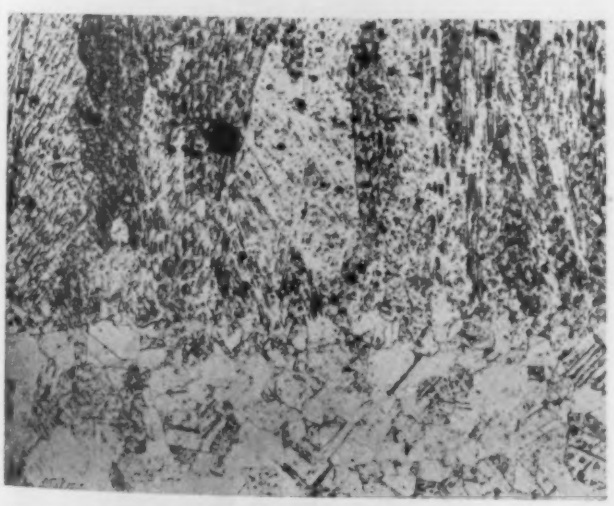


Fig. 16—Junction of Weld Metal and Base Metal of Weld in Fig. 15. Note the Intergranular Bond Between Weld Metal and Base Metal Indicating Positive Fusion. Mag. 50 ×. Etchant—Chromic Acid

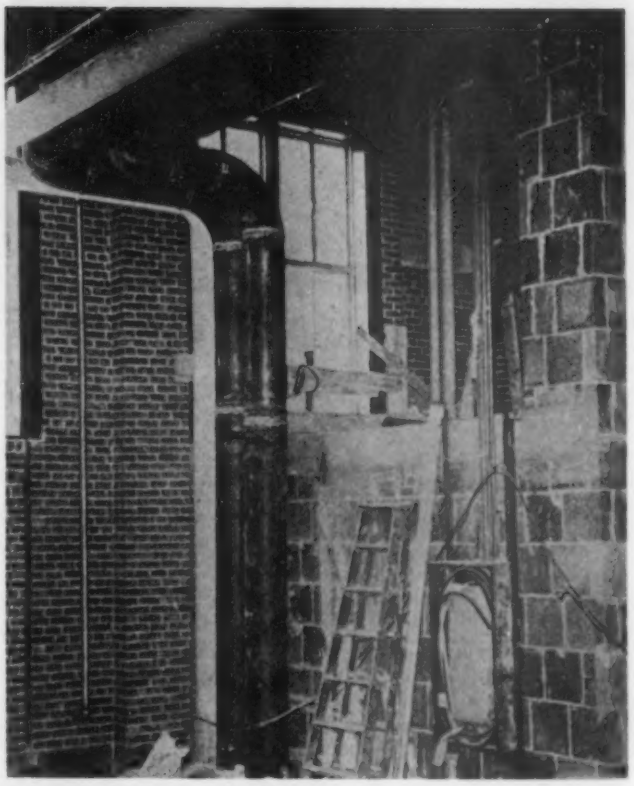


Fig. 17—8-In. Diameter Red Brass Pipe Installed by Oxyacetylene Welding Using Low Silicon Bronze Welding Rod. Weld Joints Illustrated Were Made in the Vertical Horizontal Position as Shown

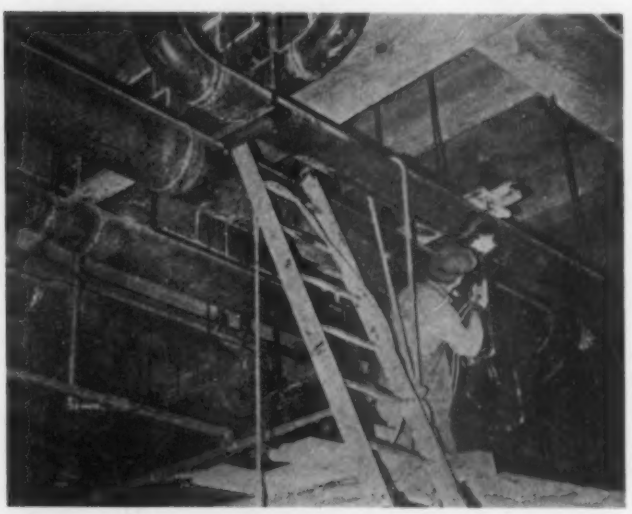


Fig. 18—10-In. Diameter Red Brass Pipe Being Welded in Overhead Position Using Low Silicon Bronze Welding Rod and the Oxyacetylene Method of Welding

Welding of Bronzes

There has been considerable information published on the arc welding of silicon bronzes (copper-silicon alloys)

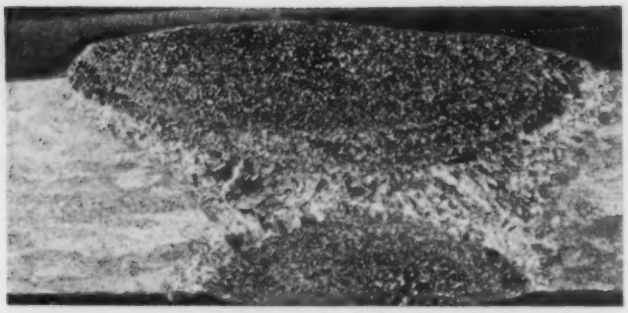


Fig. 19—Carbon Weld on $^3/_8$-In. Muntz Metal Using Low-Fuming Bronze Welding Rod. Note the Small Granular Structure of the Weld Metal. Mag. 2.5 ×. Etchant—H_2O_2 + NH_4OH

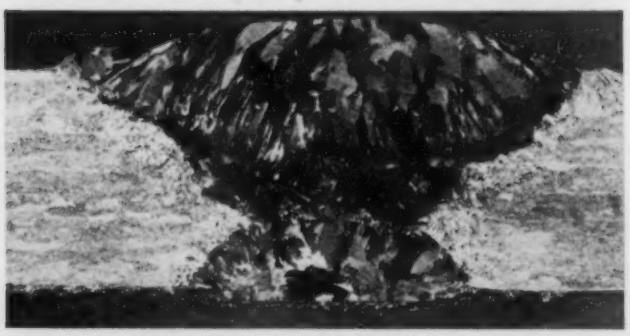


Fig. 20—Carbon Arc Weld on $^3/_8$-In. Muntz Metal Using High Silicon Bronze Welding Rod. Note the Large Granular Structure of the Weld Metal, Indicative of Greater Ductility. Mag. 2.5 ×. Etchant—H_2O_2 + NH_4OH

and it is not the purpose of this paper to discuss the welding of this type of alloy. There have been no new developments in this welding and the previously recommended procedures have rendered excellent results.

Phosphor bronzes can be satisfactorily welded by the metal arc or carbon arc-welding methods. A coated phosphor-bronze rod for metal arc welding is recommended and is commercially available from welding electrode manufacturers. For carbon arc welding, the high-silicon-bronze welding rod gives better results from a welder's standpoint than phosphor-bronze rod. Considerable trouble is encountered in keeping the highly fluid weld metal free from slag inclusions when using phosphor-bronze rod. The reason for this is the higher welding speeds that must be used with the more fluid weld metal, thus minimizing the length of hesitancy with the arc to cause the slag particles to rise to the surface Microscopic and X-ray examination reveals the slag particles at the weld junction. This trouble is not experienced with the high-silicon-bronze rod since welding speeds can be controlled so that the slag inclusions can be easily removed from the weld metal.

Aluminum bronze and beryllium bronze are very difficult to weld by the oxyacetylene and carbon arc method using a welding rod of similar alloy composition as the base metal. Both alloys form highly refractory oxides which are difficult to slag off with flux. Aluminum oxide forms a light tough web which becomes folded in the flowing weld metal and does not rise to come in contact with the molten flux on the surface of the weld metal. Satisfactory results can be obtained using the carbon arc method with the high-silicon-bronze welding rod. Because of the minimum disturbance of the base metal, very little oxides of aluminum or beryllium are formed to effect the flowing property of the weld metal. Using a silicon-bronze flux, excellent weld metal densities are obtained. These alloys are also being welded with excellent results using coated aluminum-bronze electrodes and the metal arc method.

Oxyacetylene welding of all the bronzes mentioned should be avoided because of various difficulties very apt to be encountered. Carbon arc welding should take preference in all cases with the exception of the aluminum bronzes and beryllium bronzes where metal arc would yield better results. If installation of units necessitates welding overhead, carbon arc welding using the high-silicon-bronze rod could satisfactorily be used but the ease of welding is not as great as when welding in the downhand position. Silicon bronze can be welded satisfactorily by the oxyacetylene method using the high-silicon-bronze rod, but should only be used when the carbon arc method is too difficult for the operator to handle. For all of the other bronzes, if arc methods cannot be used, it is suggested that brazing using the yellow brass brazing rods or silver alloy brazing rods be used. This recommendation is made providing the service encountered will permit the use of the yellow brasses, particularly from a corrosion resistance standpoint.

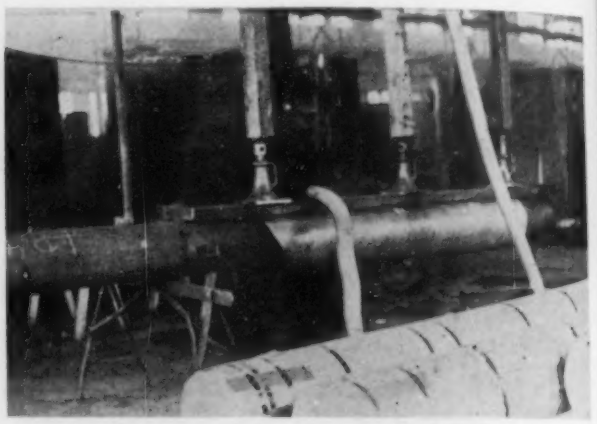
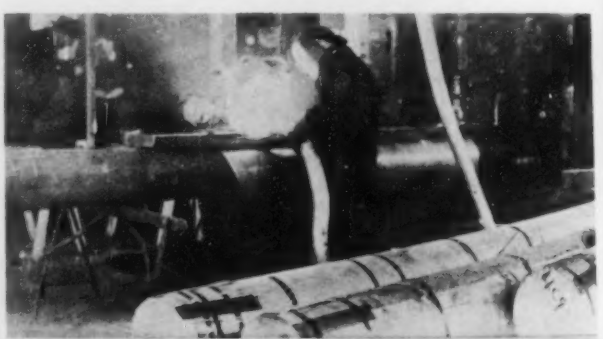


Fig. 21—Set-Up for Carbon Arc Welding Fabrication of 14-In. and 16-In. Diameter Muntz Metal Piping



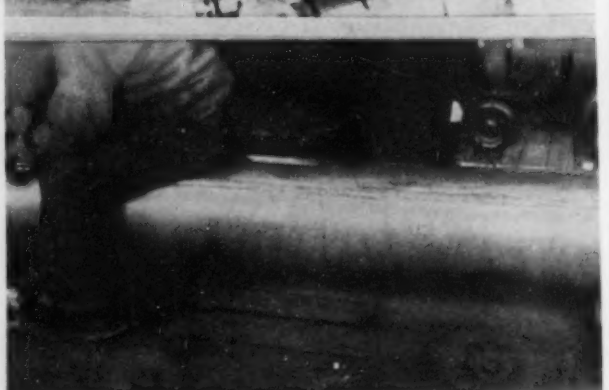


Fig. 22—Carbon Arc Welding $^3/_8$-In. Muntz Metal Using High Silicon Bronze Welding Rod in Fabricating 14-In. Diameter Piping

Fig. 23—Completed 14-In. Diameter Piping Shown Being Welded in Fig. 22

Welding as It Applies to Railroads*

By Robert Moran†

IN preparing this paper the thought occurred to me that I should write it as though we were having a friendly chat and I was asked just what part does welding play on our railroads today.

At the outset I would be lost or dazed because of the magnitude of the request for the reason that our welding shops and rails cover all states in the Union, costs and figures of the various operations being done in the many units of the railroads are not generally kept, but a fairly accurate check on cost is made at the introduction of practically all of the major operations when adopted as a standard welding practice.

Through the older members of this organization you can go back to the introduction of welding as a repair tool, not only on railroads but in the shipyards, foundries, boiler shops, the wayside garage, oil refineries, street railways and the many other industries throughout the land all resorting to the use of welding as a medium of repair. Without it the efficiency of the United Nations as a fighting and industrial unit would be seriously jeopardized. It is practically impossible to name anything as a tool of war that does not have some type of welding in its design. The mighty fighting units of our Navy, gun turrets, gun mounts, tanks, submarines, cargo vessels, the landing gear of our mighty airplanes, invasion barges and countless other items are either entirely constructed by welding or welding is used partly in the design.

Welding is no longer a repair tool, for with it we are able to weld together the many hull plates, bulkheads and deck plates into a finished giant cargo vessel. In our industrial life welding is indispensable, for without it the cost of maintaining our right-of-way rolling stock, bridges, work equipment and the countless other items so necessary to the operation of a railroad would be greatly increased, so with all this I feel that we are all agreed that welding is a mighty important subject. So important that I feel we can truly call it the industrial giant of the day.

First, we will discuss that part of the railroad known as the maintenance of way and the welding they do to keep the rails, crossings, frogs, switch points and other appurtenances in this classification in a safe and serviceable condition.

The method of procedure and the materials used in the welding of these parts are very similar on all the American railroads as is the personnel who are charged with the supervision and the training of competent men for the various classifications of work necessary to complete the units or gangs to handle this type of work. The oxyacetylene process is used principally in the building up of the worn or battered rail ends; this has been extended to the welding of rail ends together. Two methods are in use, the manual oxyacetylene method and a method using oxyacetylene for thermal energy together with applied pressure, this method, together with the manual oxyacetylene method, unquestionably makes a smoother riding road bed and will certainly reduce the cost of maintenance to this particular item. Another important item in connection with the welded rail joint is that cracks or fissures can be detected throughout the entire rail; such is not the case with the open joint and rail angle bar assembly.

Switch points and frogs are restored to standard dimensions by the oxyacetylene process. Grinding is resorted to obtain a smooth workmanlike finish. This class of work is generally handled at some centralized point where conditions and equipment are available to do a first-class job.

Signal Department

The signal department in the reconditioning and repairs to equipment employs the use of the oxyacetylene method principally due to the particular items being of cast-iron design. Some of the items repaired are: signal bootlegs, circuit controller cases, operating cams on switch circuit controller, crossing bells and instrument cases of signal equipment.

Water Service Department

This unit of the railroad is charged with the duty of installing and maintaining all water, compressed air lines, heating lines and fuel lines. Since the introduction of welding this department has taken advantage of the more modern method of joining pipe lines and uses both the oxyacetylene and the electric arc method in new installations and in the maintenance of the old pipe-line installation.

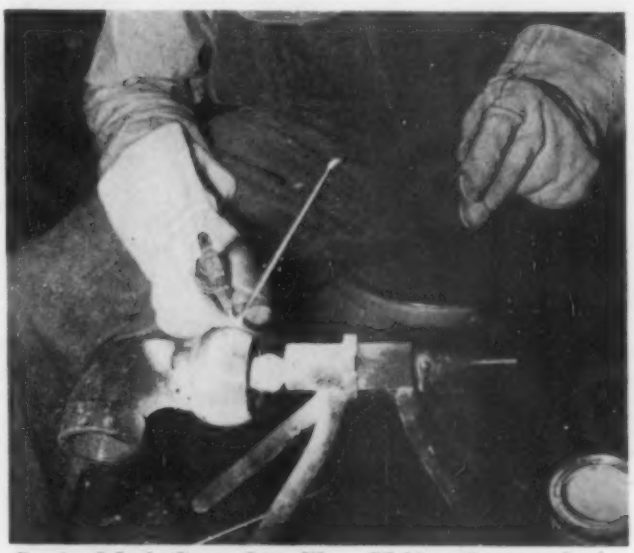


Fig. 1—A Little Goes a Long Way. Welding Operator Applying Bronze to Wearing Surface of a Flexible Ball Joint

* To be presented at the Annual Meeting, A.W.S., Chicago, Ill., Oct. 18 to 21, 1943.

† System Welding Supervisor, Missouri Pacific Lines, St. Louis, Mo.

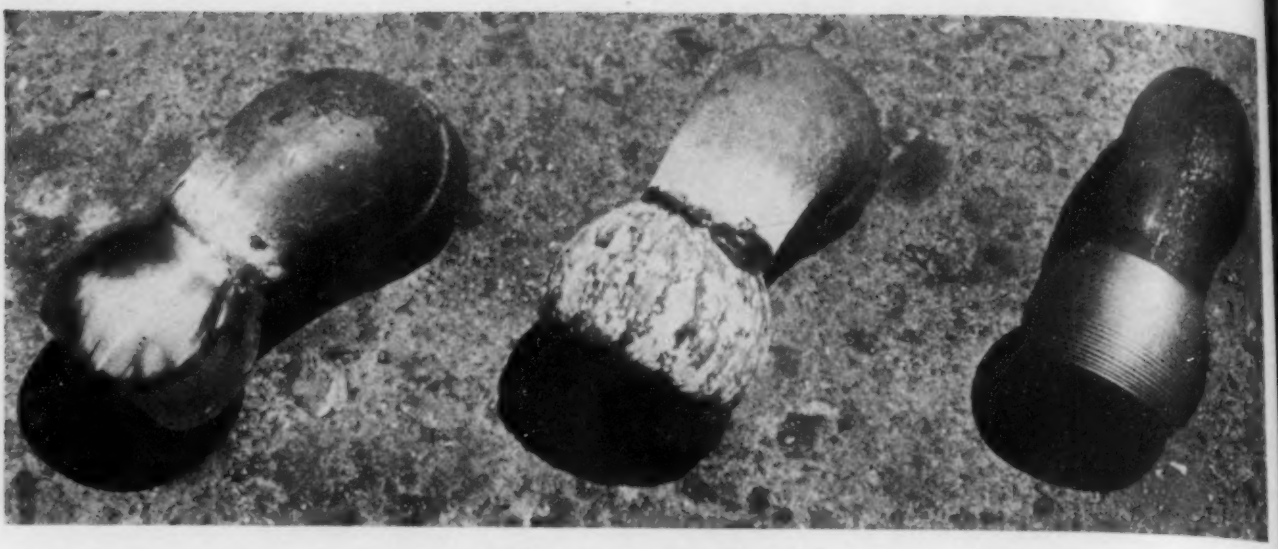


Fig. 2—Steps in Repair

(Right to left) *(a)* Worn ball joint turned down in preparation for welding. *(b)* After application of bronze by oxy-acetylene welding. *(c)* The weld metal is then turned down to correct fit.

On December 7, 1941, and up to the present minute the users of metal parts, whether it be castings, forgings billets, round or square iron, tank steel or firebox steel were asking the question, "What are we to do if we can't get this material?" As we all know, the situation isn't so bad that we are denied the material, but the uncertainty of when the delivery could be made was the chief concern. This resulted in countless meetings between manufacturers, purchasers and the user, calendars hanging on the office walls then came into practical use—Time was the factor. It is needless for me to explain the necessity of the railroads to the Nation as a carrying agent or a transportation system, they have to deliver the goods, and in order to do this they have to maintain their equipment in such a way that it will stand up to the heavy demand it is called upon to perform.

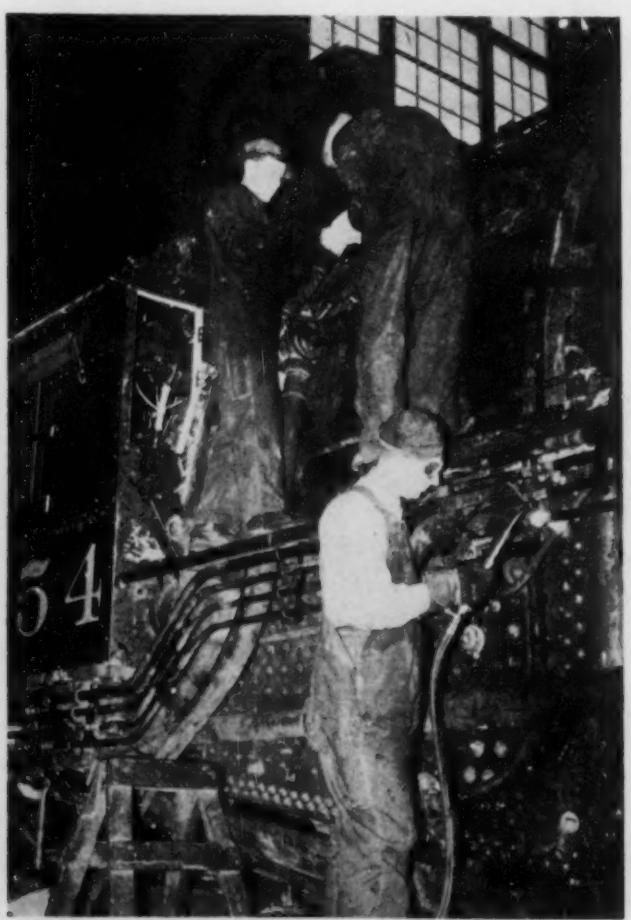


Fig. 3—In Addition to Its Use by the Water Service Department, Welded Piping Provides Trouble-Free Service on Locomotives

To meet the situation relative to the inability to secure certain items for the repairs and maintenance of rolling stock, standards were revised to meet the situation with very careful consideration being given to the safety of operators and passengers in the change.

In the case of castings fabricating was resorted to. Some of the outstanding or major items manufactured are locomotive cylinders, locomotive frame cross ties, passenger and baggage car pedestals. Other items manufactured by the flame-cutting process are locomotive cross heads, valve cross heads, driving boxes, locomotive and passenger equalizers, etc. To further increase the service life of locomotive parts subjected to friction wear consideration was given to hard surfacing and the more modern method of flame hardening with the thought of better performance and cheaper maintenance. To properly maintain and meet the specifications of classified repairs to locomotives, tenders, passenger and baggage cars, freight cars and gondolas, both the oxyacetylene and the electric arc methods of welding are being resorted to in a larger degree than ever before. Procedure control and specifications on the additional items necessary in the repairs to rolling stock due to inability of securing same and the probability that the materials necessary in the manufacture of these items were being diverted to more strategic materials were strongly emphasized. Cost of reclamation or repairs is secondary. When we speak of reclamation on railraods, our thoughts naturally turn to welding as a medium of process to fix or repair the worn or broken article. Reclamation and welding are closely allied. Not so long ago the first consideration we would give in determining the value of reclamation was the cost and the service life of the article to be reclaimed or reconditioned. The cost was determined by adding the scrap value of the article to the cost of the material, labor and shop overhead involved in repairs. If the margin of saving was small, or the cost approached the new price of a similar article then the service life would

Fig. 4—Vibration Due to Heavy Traffic Makes Little Difference to This Smooth, Efficient, Welded Piping Installation

have to compare favorably with a new article before it was entertained as a likely article for reclamation. Times have changed and we are forced to reclaim in some cases at a loss, first, as a necessity for maintaining our equipment due to the scarcity of steel and, second, as a patriotic effort.

This condition is going to involve deeper thinking on the part of those who are charged with the responsibility of getting the "Go Ahead" signal on items to be reclaimed. It is quite true we have two regulatory bodies, the A.A.R. and the Bureau of Locomotive Inspection, who define just how far we may go in the welding of parts on locomotives and cars, but in our enthusiasm to get things done we are apt to neglect taking into consideration the safety angle which is paramount in the operation of our railroads. Human nature is the same now as it was 2000 years ago and let us not forget that we are constantly confronted with the human element, which is more or less the unknown factor in manual arc or oxyacetylene welding, and even though in some cases we are forced to use qualified operators on certain classes of work a definite procedure of control should be employed to suit the particular job.

During the month of August 1942, the rules pertaining to the welding of car parts were modified to permit a greater latitude of welding on such parts as cast steel bolsters, yokes, couplers, etc. This was made possible after repeated tests had been conducted to determine the physical properties of welds under service conditions, and was a token of the farsightedness of this committee in foreseeing a possible shortage of these items, and the possibility that the metal necessary in the manufacture of these items would be diverted into articles necessary in the conduct of the war. There may be more modifications to permit still greater amounts of welding before Victory has been achieved, so it behooves us all, especially those of us who have supervision and have welding under our jurisdiction, to live up to the rules especially so in securing qualified welding operators to weld on such parts as were designated by the committee. This is truly a step in the right direction and will not only pay dividends to the railroads from a monetary standpoint but also from peace of mind.

Fig. 6—Another Wartime Material Economy. Shape Cutting Makes Available Parts Which Cannot Be Purchased These Days. Nearing the End of the Cut on a Coach Equalizer

Fig. 5—A Few Ounces of Welding Rod Save a Costly Equipment Replacement. Building Up Worn Seats in an Injector Body

The "M of E" or the maintenance of equipment falls into the category of the mechanical department and has to do with the upkeep of locomotives, tenders, passenger equipment, freight equipment, Diesel equipment and work equipment which includes wreckers, clam shells, ditchers, spreaders, pile drivers, drag lines and tractor equipment of various kinds, and the maintenance of power plants at various points on the railroad generally is maintained or comes under the jurisdiction of the mechanical department.

How should welding be controlled on these various items so as not to conflict with the various rules and regulations as designated by the Bureau of Locomotive Inspection and the A.A.R.? Every railroad should have an organization or a committee who could meet periodi-

cally to discuss welding practices and problems. They should be charged with the responsibility of not only suggesting and approving of welding practices but also be the medium through which the committee rules and standard practices be enforced. The welding committee should consist of one or two mechanical superintendents, mechanical engineer, engineer of tests, superintendent of car department or the master carbuilder, chief mechanical inspector, chief boiler inspector, the forging supervisor or general blacksmith foreman and the chief welding supervisor. Each is placed on the committee due to his particular knowledge as head of his department; for instance, if a suggestion were made at a committee meeting relative to welding some part of motion work, the chief mechanical inspector would approve or disapprove according to his interpretation and knowledge of the rules pertaining to welding on parts as defined by the Bureau of Locomotive Inspection. The same thing applies to boilers. The chief boiler inspector is there to protect his class of work and

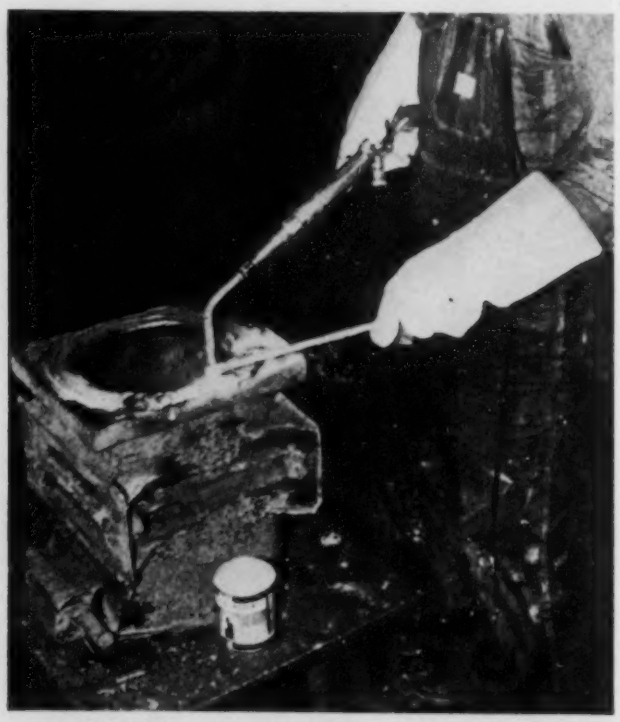


Fig. 7—Building Up a Worn Coach Journal Box with Bronze Welding Rod Restores Another Piece of Equipment to Help War Transportation

will not approve of suggestions that conflict with rules and practices that are considered necessary for a safe and suitable method of repair. The engineer of tests has knowledge of metals and is invaluable in this respect; likewise the chief mechanical engineer will advise on design from the engineer's stand-point. The forging supervisor with his knowledge of the working qualities of the various steels used and their heat treatment is a great asset to a committee of this kind. He can advise on preheat and stress-relieving temperatures and can assist greatly in formulating a procedure of welding. So with a committee of this kind you have a rich and abundant source of information and experience with which to draw from at a committee meeting.

Welding practices on all railroads are pretty much the same in that similar items are welded or reclaimed by a method of procedure to suit conditions at the point at which work is being done. A welding practice should not be permitted until it has been handled by the welding

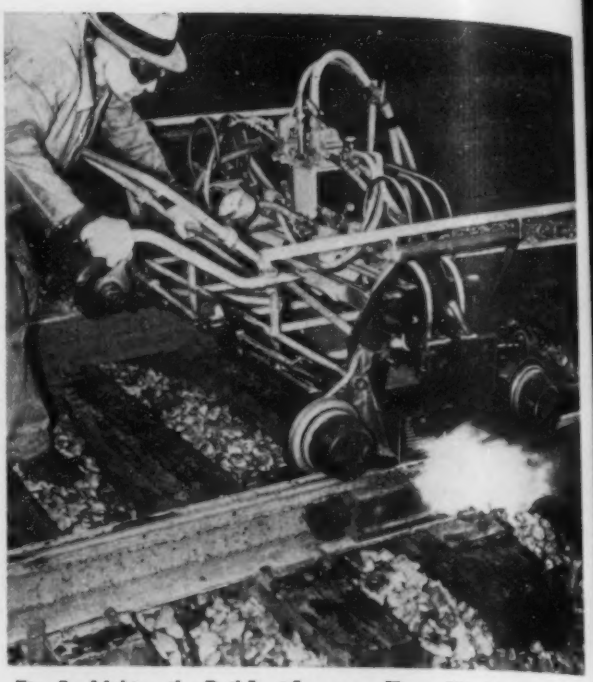


Fig. 8—Making the Rail Last Longer. Flame Hardening of Rail Ends Adds to the Life of Rail Without Use of Critical Metals

committee and approved by the chief mechanical officer. Welding practices, like mechanical standards, are the results of tests conducted to determine the best practical method of procedure to follow in order to bring to completion a safe and practical job. It would be impractical to permit all our mechanics to do the job in the way or manner he thought was best. It would likewise be insane to permit welding to be done without any method or procedure. The results would be countless engine failures. However, even though we have definite rules and procedures for the various weld-

Fig. 9—Building-up of Rail Ends in Track by Welding Postpones the Need of New Rail Purchases

ng practices the welding committee should have an pen mind on the subject and be receptive to ideas and uggestions which would tend to be an improvement ver present practices. The welding personnel in the hops should be encouraged to make suggestions to the nd that welding will be done more safely, economically nd practically.

The welding operator should undergo some type of elding test which would qualify him for the work in is particular department. The railroads of the middle est, to my knowledge, do have a qualifications test imilar to the approved A.W.S. test. These tests are ot given with the thought of running men off the job ut to make better welding operators. At the introduction of the qualifying of welders on the Missouri Pacific it was astounding to find that men we considered ood old-time operators made the poorest grades and hen the news got around the psychological effect it had as more astounding than ever. The older operators anted to be looked upon as qualified welders from a ractical point and ability and later on did prove that hey could qualify.

Tests were conducted semi-annually. This has been hanged and eliminates a qualified welder from making urther test coupons. He will make them only at the discretion of the shop superintendent, master mechanic or welding supervisor. This measure was put into effect to save precious materials and man-hours, not only on the part of the welding operator, but also of the men who prepare and finish the test coupons. It is expected that this practice will be canceled at the end of the war and revert back again to the semi-annual test.

The subject of how welding practices are originated and put into effect, together with the qualifying of the welders, has been touched upon. Materials such as welding rods and electrodes, their size and grades and amounts should have the approval of the party responsible for welding before the purchase order is made and approved, for the reason that he has a general knowledge of the welding programs in effect and programs planned months ahead. If this course is not taken sizes and grades are generally ordered that don't move fast. The results will be—when this commodity is purchased in carload lots the fast-moving size will be used leaving the larger sizes still in stock, and when you cry to the high heavens for more $^{5}/_{32}$ or $^{3}/_{16}$ in., the WPB penalizes you and points out you have so many tons of welding wire on the last invoice date and you consumption is so many tons a month, therefore, we can't approve of another request by you to purchase more welding wire. Seriously, gentlemen, this is an item which should be policed and if properly handled it will eliminate a lot of correspondence and help create a harmonious feeling between the users and they who have the authority to say whether you can or you can't purchase it.

I would like to mention at this time that the mechanical personnel of the roads I am acquainted with are very appreciative of the wonderful assistance gained from the reports and papers of the various fact-finding committees of this SOCIETY. They rely on this information and use it in their specifications for they know that the members of these various committees are very competent and are making it their vocation to the end that welding will be more generally understood and simplified so that more welding operations can be performed with the assurance of success.

Reclamation by Hard Facing*

By F. G. Jones†

HARD facing is the placing of an overlay of metal which is inherently hard and wear resistant or corrosion resistant, on a metal part not possessing these qualities, or on a part possessing these qualities but worn or corroded to the point where it may be unserviceable. This overlay is usually applied to the part by welding, either by oxyacetylene welding, metal arc welding, carbon arc welding or furnace welding.

Oxyacetylene welding of a hard facing overlay material is usually done with a standard oxyacetylene welding outfit, although some manufacturers of welding equipment have designed special tips for applying hard facings. Oxyacetylene welding is generally used when applying the non-ferrous hard facings. Metal arc welding is used when applying most ferrous base hard facings, although the non-ferrous hard facings have been applied in this manner in cases where the part to be hard faced was of such size or shape as to be unusually difficult to hard face by the oxyacetylene process. Carbon arc welding is used on some types of hard facings which are supplied in paste or powder form. These hard facings are spread on the part to be hard faced and fused into the part with the carbon arc. This method, in reality, forms an alloy of the hard facing particles and the base metal. This method is usually used where the part which is hard faced can be placed in service in the "as-welded" condition. The various methods of furnace welding or furnace brazing have been found more suitable for applying hard facings to small parts, or to large quantities of duplicate parts. In this method a casting of hard facing metal is bonded directly to the part to be hard faced, if the alloy lends itself to this method, or the casting of hard facing metal is bonded to the part by low-temperature brazing or copper brazing. The method of application of the hard facing overlay must be determined from the type of hard facing to be used, and the size and number of pieces to be hard faced. Very large parts have been successfully hard faced by the oxyacetylene process when properly prepared and handled.

Hard facing materials are manufactured in several types and grades. The various types are manufactured for wear resistance, corrosion resistance, impact resistance, resistance to erosion, or combinations of these qualities. The proper type must be chosen so that it will perform the service required. The various grades are manufactured to suit conditions under which the hard facing overlay must be put in condition for use. In most cases, the hardest possible grade is chosen, if it meets the requirements as to type. Usually, these hard grades must be ground. If the part to be hard faced is such a

* To be presented at the Annual Meeting, A.W.S., Chicago, Ill., Oct. 18 to 21, 1943.

† Wall-Colmonoy Corp., Chicago, Ill.

shape or size that it is not practical to grind it, then a softer grade, which can be machined, should be chosen. In most cases, the oxyacetylene deposited non-ferrous hard facings offer a greater choice along this line.

The various types of hard facings are alloyed in their various combinations for definite reasons. The non-ferrous alloys, such as the chromium-boron-nickel alloy, or the chromium-tungsten-cobalt alloy, are designed for corrosion and wear resistance, and resistance to erosion at high temperatures. The ferrous base hard facings seem to be less suitable for high-temperature operations, but have definite advantages, in most cases, where there are severe impacts, or a succession of milder impacts along with abrasion.

Serious consideration should also be given to hard facing of new parts, especially under the present conditions. Many times a new part is designed of an alloy steel, in order to harden the part, or a portion of it, to resist wear or abrasion. If it were designed for hard facing, the part often can be plain carbon steel, hard faced where the wear occurs. New parts which are hard faced usually outwear a hardened steel part many times, and also use less of the now so urgently needed strategic raw materials.

The essential use for hard facings, under the present emergency, is to save our supply of strategic elements. Some of the hard facings available use no strategic raw materials whatever, and serious consideration should be given to the possibilities of using these materials.

As an example of the value of hard facing methods for reclamation purposes, one machine part which must remain unnamed, but weighed 46 lb., required only $2^1/_2$ lb. of non-ferrous hard facing material to reclaim it, applied by the oxyacetylene process. It required 183 lb. of rolled alloy steel plate to produce a new part.

Other examples of the saving of strategic alloys are as follows: forming rolls, forming $^1/_4$-in. thick hot-rolled steel plate, were made of oil hardening tool steel, hardened to 65 Rockwell "C." These rolls were hardened in an attempt to prevent wear, but there was considerable breakage. These worn and broken forming rolls were reclaimed with a non-ferrous hard facing alloy, of only 40 Rockwell "C" in hardness. These hard-faced rolls have operated as long as the hardened steel, with no breakage. The 40 Rockwell "C" material made it possible to machine the reclaimed rolls. The reclamation required from 4 to 6 lb. of hard facing alloy, whereas it required about 70 lb. of tool steel to make a new roll.

Another example of the reclamation made possible by hard facing, is the reclamation of hammer mill hammers. In one case, hammers pulverizing an asbestos product, were made of hardened high-speed steel. This material would operate successfully for three months. These hammers were hard faced with ferrous base hard facing, applied by oxyacetylene welding. The reclaimed hammers lasted 6 mo. The few pounds of hard facing saves many times its weight in high-speed steel, which certainly is strategic at the present time.

Another example of the reclamation of hammers for hammer mills, is that of 39 manganese steel hammers. These hammers were hard faced with 6 lb. of a paste form of hard facing material, applied by the carbon arc process. These hammers were then maintained in good condition by applying $1^1/_2$ lb. of the same material, 15 applications in all. The hard faced hammers crushed 158,000 tons of cement rock. The hammers, when not hard faced, would only crush 77,000 tons. The paste hard facing used in this case contains no strategic material.

One example of the value of hard facing new parts, is that of induced draft boiler feed fans. These fans, when made of alloy steel plate, would operate about 4 mo. A paste type hard facing, applied by carbon arc, increased the life of these fans to 17 mo. The hard-faced fans were plain construction or boiler plate, and the paste type hard facing contained no strategic material.

An example of the use of corrosion-resistant and wear-resistant hard facing is in the use of large cock valves used in corrosive solutions in oil refining. Corrosion-resistant steel valves required relapping, to seal them so they would shut off, every 6 mo. The same type valves, hard faced with a non-ferrous hard facing alloy by the oxyacetylene process, have been in operation over 18 mo. without relapping. The original corrosion-resistant steel valves are now to be reclaimed with the same hard facing material.

Turbine type pumps, made of corrosion-resistant iron alloys, used in coke by-products plants, have been reclaimed with a non-ferrous hard facing alloy by the oxyacetylene process, and the reclaimed pumps last more than three times as long as they did originally.

Draw dies 15 in. O.D. x $7^3/_4$ in. I.D. x $3^1/_{32}$ in. thick, were hard faced with 14 lb. of non-ferrous hard facing in 9 hr. by oxyacetylene welding. These dies are heated to 400° and a very thin layer of hard facing material applied, known as a tinning coat. The dies are then heated to 1200° F. The welding progresses, building up the hard facing so that it will finish $^3/_{16}$ in. thick. If the die cools below a visible red heat, the welding is stopped, and the die reheated to 1200° F. Before hard facing, hardened tool steel dies lasted only 30 days, and the dies had to be repolished every day. After hard facing, the dies ran 30 days before repolishing. A hard faced die put in operation Dec. 15, 1942, was still operating on Aug. 3, 1943.

Another example of the savings made possible by hard facing, is that of a large automobile fender die which was altered at the change of models by the use of a machinable grade non-ferrous hard facing. This die was built up at one point approximately 2 in. thick. This build-up tapered off to nothing about 2 ft. each way. About 50 lb. of hard facing was required to do this job and this saved a new 3000-lb. casting of alloy cast iron, all the machining and the alteration of the pattern, if not a new pattern.

Machine parts, used in the production of war material, can be reclaimed very easily. In one case, a high-speed lathe center was being reground each day. This center, when worn, was hard faced and ground at a cost of $2.00. After hard facing, it needed to be reground only every 21 days. This was a No. 3 Morse Center.

The main requirements of a hard facing seem to be that it must have a low coefficient of friction, it must not flow under pressure or impact and a low coefficient of expansion is desirable. It need not possess work hardenability, although for some uses this is quite desirable. It should also have a very high resistance to galling against itself or against other materials.

Many parts, other than those listed above, can be reclaimed at a cost not higher than a new part, with the advantage of the additional life, and it seems quite urgent, during the present emergency, that each and every user of machine parts do his best to save strategic materials by the use of hard facings.

Locomotive Parts Fabrication and Welding of Bronze Bearing Surfaces*

By J. W. Kenefic†

WHEN the national emergency period first descended upon American industry it created an unusually pressing problem for the railroads. They, more than almost any other industry, have a constant maintenance problem of large proportions. To keep locomotives and rolling stock operating efficiently and with a wide margin of safety requires frequent repairing and replacement of numerous parts. To complicate the position of the railroads even further, they were for a time handicapped by a comparatively low priority position, which made it doubly difficult to obtain replacement parts through the customary channels.

Because of these factors the railroads found it necessary to embark on an extensive program of fabricating their own replacement parts on the one hand, and of rebuilding or reclaiming worn-out parts on the other. Much of this work was, at that time, quite new and untried. It can be said now, with great credit to railroad shop personnel, that they coped with these problems in a very progressive manner. They have applied welding, brazing and other oxyacetylene processes in maintenance work in such ways as to create not merely acceptable substitutes for standard parts, but often an improved part—lighter, stronger or more durable than the original.

So numerous is the variety of parts which can and have been fabricated or reclaimed by welding that it will be impossible to give details here on more than a few. For the most part these will be confined to locomotive parts. One railroad has compiled a list of 350 locomotive parts, to determine how many could be made by flame cutting and welding. This list was divided into four classifications: first, parts which are more economical to fabricate than to purchase; second, parts whose cost of fabrication in the shop is equal to outside purchase price; third, parts which cannot be obtained except by shop fabrication; and fourth, parts not to be considered. It was found that about 90% of the parts fell into the first three groups, that is, either through necessity or economy it was desirable to fabricate these parts by welding.

In addition to fabrication of new parts there is considerable activity in repairing of cracked or broken castings, as well as restoration of worn areas or moving parts by means of building up these surfaces with steel or bronze weld deposits. A number of such applications will be described and illustrated.

Lead-Bronze Welding Rod

Bronze bearing metals for electric arc application on certain wearing surfaces on locomotive parts were introduced to the railroads six or seven years ago. Since then the merits of these applications have been proved many times over. The operations described in this article have all been in use for a year or more, and are accepted as standard practice. Other applications are in the process of being tested and as soon as they are proved worth while they, too, will be accepted as standard operations.

The bronze weld metal used for these purposes is of a type developed specifically for giving a satisfactory bearing surface for those parts of the locomotive, such as driving box laterals and crowns, which are subjected to unusually severe service conditions. This self-fluxing, lead-bronze electrode is particularly suited as a bearing metal because of its high lead and tin content. It is of substantially the same analysis as the brass which is customarily poured in on driving box laterals.

This bronze can be applied with a carbon arc or by the

Fig. 1—Building Up a Driving Box Lateral by Metallic Arc Welding with Self-Fluxing Lead-Bronze Bearing Metal

* To be presented at the Annual Meeting, A.W.S., Chicago, Ill., Oct. 18 to 21, 1943.

† Superintendent, Railroad Service, Western Division, Air Reduction Sales Co.

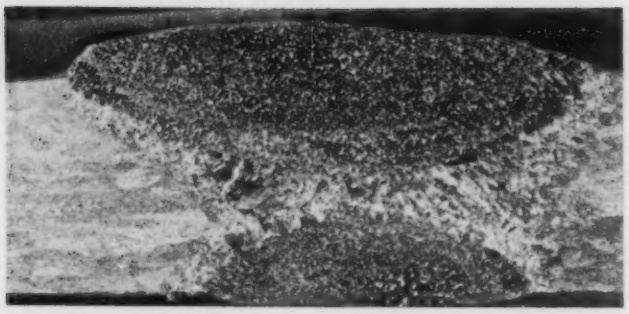


Fig. 19—Carbon Weld on 3/8-In. Muntz Metal Using Low-Fuming Bronze Welding Rod. Note the Small Granular Structure of the Weld Metal. Mag. 2.5 ×. Etchant—H_2O_2 + NH_4OH

Fig. 20—Carbon Arc Weld on 3/8-In. Muntz Metal Using High Silicon Bronze Welding Rod. Note the Large Granular Structure of the Weld Metal, Indicative of Greater Ductility. Mag. 2.5 ×. Etchant—H_2O_2 + NH_4OH

and it is not the purpose of this paper to discuss the welding of this type of alloy. There have been no new developments in this welding and the previously recommended procedures have rendered excellent results.

Phosphor bronzes can be satisfactorily welded by the metal arc or carbon arc-welding methods. A coated phosphor-bronze rod for metal arc welding is recommended and is commercially available from welding electrode manufacturers. For carbon arc welding, the high-silicon-bronze welding rod gives better results from a welder's standpoint than phosphor-bronze rod. Considerable trouble is encountered in keeping the highly fluid weld metal free from slag inclusions when using phosphor-bronze rod. The reason for this is the higher welding speeds that must be used with the more fluid weld metal, thus minimizing the length of hesitancy with the arc to cause the slag particles to rise to the surface Microscopic and X-ray examination reveals the slag particles at the weld junction. This trouble is not experienced with the high-silicon-bronze rod since welding speeds can be controlled so that the slag inclusions can be easily removed from the weld metal.

Aluminum bronze and beryllium bronze are very difficult to weld by the oxyacetylene and carbon arc method using a welding rod of similar alloy composition as the base metal. Both alloys form highly refractory oxides which are difficult to slag off with flux. Aluminum oxide forms a light tough web which becomes folded in the flowing weld metal and does not rise to come in contact with the molten flux on the surface of the weld metal. Satisfactory results can be obtained using the carbon arc method with the high-silicon-bronze welding rod. Because of the minimum disturbance of the base metal, very little oxides of aluminum or beryllium are formed to effect the flowing property of the weld metal. Using a silicon-bronze flux, excellent weld metal densities are obtained. These alloys are also being welded with excellent results using coated aluminum-bronze electrodes and the metal arc method.

Oxyacetylene welding of all the bronzes mentioned should be avoided because of various difficulties very apt to be encountered. Carbon arc welding should take preference in all cases with the exception of the aluminum bronzes and beryllium bronzes where metal arc would yield better results. If installation of units necessitates welding overhead, carbon arc welding using the high-silicon-bronze rod could satisfactorily be used but the ease of welding is not as great as when welding in the downhand position. Silicon bronze can be welded satisfactorily by the oxyacetylene method using the high-silicon-bronze rod, but should only be used when the carbon arc method is too difficult for the operator to handle. For all of the other bronzes, if arc methods cannot be used, it is suggested that brazing using the yellow brass brazing rods or silver alloy brazing rods be used. This recommendation is made providing the service encountered will permit the use of the yellow brasses, particularly from a corrosion resistance standpoint.

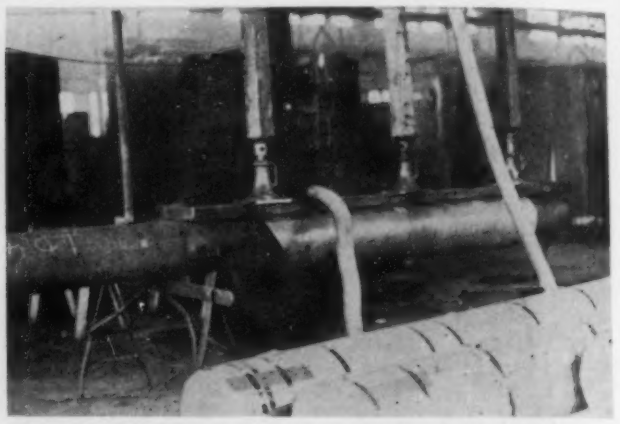


Fig. 21—Set-Up for Carbon Arc Welding Fabrication of 14-In. and 16-In. Diameter Muntz Metal Piping

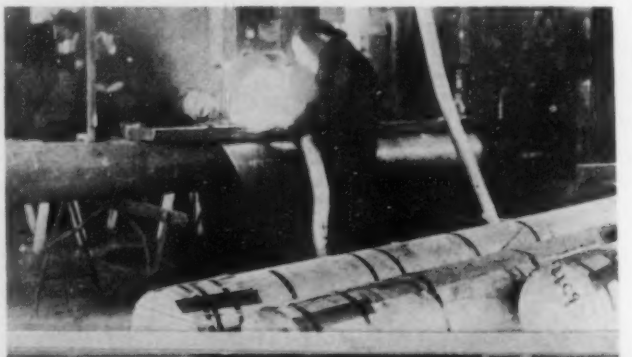


Fig. 22—Carbon Arc Welding 3/8-In. Muntz Metal Using High Silicon Bronze Welding Rod in Fabricating 14-In. Diameter Piping

Fig. 23—Completed 14-In. Diameter Piping Shown Being Welded in Fig. 22

Welding as It Applies to Railroads*

By Robert Moran†

IN preparing this paper the thought occurred to me that I should write it as though we were having a friendly chat and I was asked just what part does welding play on our railroads today.

At the outset I would be lost or dazed because of the magnitude of the request for the reason that our welding shops and rails cover all states in the Union, costs and figures of the various operations being done in the many units of the railroads are not generally kept, but a fairly accurate check on cost is made at the introduction of practically all of the major operations when adopted as a standard welding practice.

Through the older members of this organization you can go back to the introduction of welding as a repair tool, not only on railroads but in the shipyards, foundries, boiler shops, the wayside garage, oil refineries, street railways and the many other industries throughout the land all resorting to the use of welding as a medium of repair. Without it the efficiency of the United Nations as a fighting and industrial unit would be seriously jeopardized. It is practically impossible to name anything as a tool of war that does not have some type of welding in its design. The mighty fighting units of our Navy, gun turrets, gun mounts, tanks, submarines, cargo vessels, the landing gear of our mighty airplanes, invasion barges and countless other items are either entirely constructed by welding or welding is used partly in the design.

Welding is no longer a repair tool, for with it we are able to weld together the many hull plates, bulkheads and deck plates into a finished giant cargo vessel. In our industrial life welding is indispensable, for without it the cost of maintaining our right-of-way rolling stock, bridges, work equipment and the countless other items so necessary to the operation of a railroad would be greatly increased, so with all this I feel that we are all agreed that welding is a mighty important subject. So important that I feel we can truly call it the industrial giant of the day.

First, we will discuss that part of the railroad known as the maintenance of way and the welding they do to keep the rails, crossings, frogs, switch points and other appurtenances in this classification in a safe and serviceable condition.

The method of procedure and the materials used in the welding of these parts are very similar on all the American railroads as is the personnel who are charged with the supervision and the training of competent men for the various classifications of work necessary to complete the units or gangs to handle this type of work. The oxyacetylene process is used principally in the building up of the worn or battered rail ends; this has been extended to the welding of rail ends together. Two methods are in use, the manual oxyacetylene method and a method using oxyacetylene for thermal energy together with applied pressure, this method, together with the manual oxyacetylene method, unquestionably makes a smoother riding road bed and will certainly reduce the cost of maintenance to this particular item. Another important item in connection with the welded rail joint is that cracks or fissures can be detected throughout the entire rail; such is not the case with the open joint and rail angle bar assembly.

Switch points and frogs are restored to standard dimensions by the oxyacetylene process. Grinding is resorted to obtain a smooth workmanlike finish. This class of work is generally handled at some centralized point where conditions and equipment are available to do a first-class job.

Signal Department

The signal department in the reconditioning and repairs to equipment employs the use of the oxyacetylene method principally due to the particular items being of cast-iron design. Some of the items repaired are: signal bootlegs, circuit controller cases, operating cams on switch circuit controller, crossing bells and instrument cases of signal equipment.

Water Service Department

This unit of the railroad is charged with the duty of installing and maintaining all water, compressed air lines, heating lines and fuel lines. Since the introduction of welding this department has taken advantage of the more modern method of joining pipe lines and uses both the oxyacetylene and the electric arc method in new installations and in the maintenance of the old pipe-line installation.

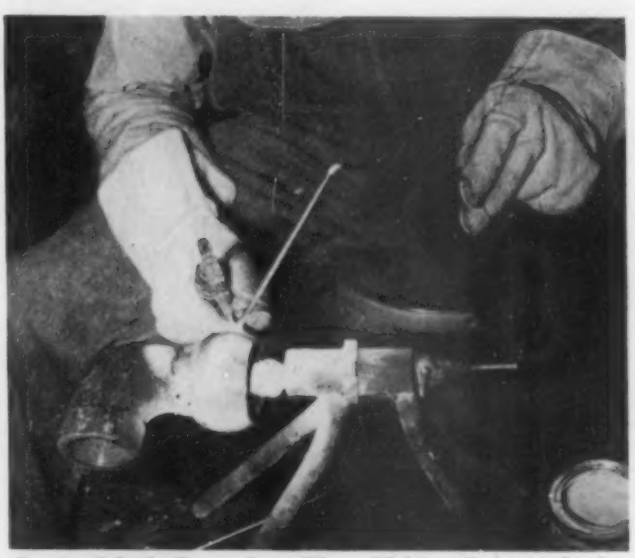


Fig. 1—A Little Goes a Long Way. Welding Operator Applying Bronze to Wearing Surface of a Flexible Ball Joint

* To be presented at the Annual Meeting, A.W.S., Chicago, Ill., Oct. 18 to 21, 1943.

† System Welding Supervisor, Missouri Pacific Lines, St. Louis, Mo.

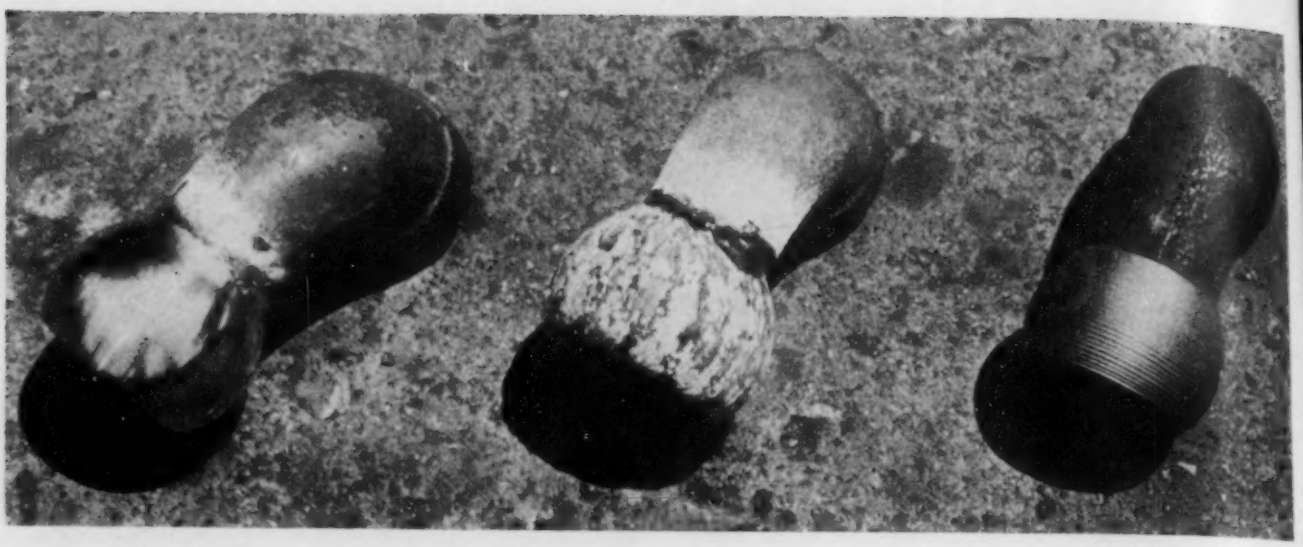


Fig. 2—Steps in Repair

(Right to left) *(a)* Worn ball joint turned down in preparation for welding. *(b)* After application of bronze by oxy-acetylene welding. *(c)* The weld metal is then turned down to correct fit.

On December 7, 1941, and up to the present minute the users of metal parts, whether it be castings, forgings billets, round or square iron, tank steel or firebox steel were asking the question, "What are we to do if we can't get this material?" As we all know, the situation isn't so bad that we are denied the material, but the uncertainty of when the delivery could be made was the chief concern. This resulted in countless meetings between manufacturers, purchasers and the user, calendars hanging on the office walls then came into practical use—Time was the factor. It is needless for me to explain the necessity of the railroads to the Nation as a carrying agent or a transportation system, they have to deliver the goods, and in order to do this they have to maintain their equipment in such a way that it will stand up to the heavy demand it is called upon to perform.

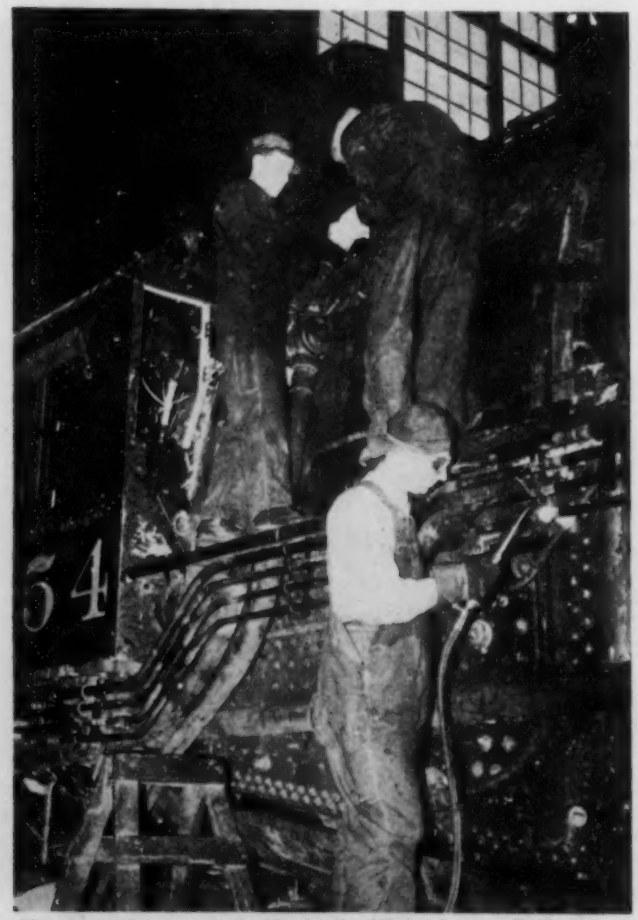


Fig. 3—In Addition to Its Use by the Water Service Department, Welded Piping Provides Trouble-Free Service on Locomotives

To meet the situation relative to the inability to secure certain items for the repairs and maintenance of rolling stock, standards were revised to meet the situation with very careful consideration being given to the safety of operators and passengers in the change.

In the case of castings fabricating was resorted to. Some of the outstanding or major items manufactured are locomotive cylinders, locomotive frame cross ties, passenger and baggage car pedestals. Other items manufactured by the flame-cutting process are locomotive cross heads, valve cross heads, driving boxes, locomotive and passenger equalizers, etc. To further increase the service life of locomotive parts subjected to friction wear consideration was given to hard surfacing and the more modern method of flame hardening with the thought of better performance and cheaper maintenance. To properly maintain and meet the specifications of classified repairs to locomotives, tenders, passenger and baggage cars, freight cars and gondolas, both the oxyacetylene and the electric arc methods of welding are being resorted to in a larger degree than ever before. Procedure control and specifications on the additional items necessary in the repairs to rolling stock due to inability of securing same and the probability that the materials necessary in the manufacture of these items were being diverted to more strategic materials were strongly emphasized. Cost of reclamation or repairs is secondary. When we speak of reclamation on railraods, our thoughts naturally turn to welding as a medium of process to fix or repair the worn or broken article. Reclamation and welding are closely allied. Not so long ago the first consideration we would give in determining the value of reclamation was the cost and the service life of the article to be reclaimed or reconditioned. The cost was determined by adding the scrap value of the article to the cost of the material, labor and shop overhead involved in repairs. If the margin of saving was small, or the cost approached the new price of a similar article then the service life would

Fig. 4—Vibration Due to Heavy Traffic Makes Little Difference to This Smooth, Efficient, Welded Piping Installation

have to compare favorably with a new article before it was entertained as a likely article for reclamation. Times have changed and we are forced to reclaim in some cases at a loss, first, as a necessity for maintaining our equipment due to the scarcity of steel and, second, as a patriotic effort.

This condition is going to involve deeper thinking on the part of those who are charged with the responsibility of getting the "Go Ahead" signal on items to be reclaimed. It is quite true we have two regulatory bodies, the A.A.R. and the Bureau of Locomotive Inspection, who define just how far we may go in the welding of parts on locomotives and cars, but in our enthusiasm to get things done we are apt to neglect taking into consideration the safety angle which is paramount in the operation of our railroads. Human nature is the same now as it was 2000 years ago and let us not forget that we are constantly confronted with the human element, which is more or less the unknown factor in manual arc or oxyacetylene welding, and even though in some cases we are forced to use qualified operators on certain classes of work a definite procedure of control should be employed to suit the particular job.

During the month of August 1942, the rules pertaining to the welding of car parts were modified to permit a greater latitude of welding on such parts as cast steel bolsters, yokes, couplers, etc. This was made possible after repeated tests had been conducted to determine the physical properties of welds under service conditions, and was a token of the farsightedness of this committee in foreseeing a possible shortage of these items, and the possibility that the metal necessary in the manufacture of these items would be diverted into articles necessary in the conduct of the war. There may be more modifications to permit still greater amounts of welding before Victory has been achieved, so it behooves us all, especially those of us who have supervision and have welding under our jurisdiction, to live up to the rules especially so in securing qualified welding operators to weld on such parts as were designated by the committee. This is truly a step in the right direction and will not only pay dividends to the railroads from a monetary standpoint but also from peace of mind.

Fig. 6—Another Wartime Material Economy. Shape Cutting Makes Available Parts Which Cannot Be Purchased These Days. Nearing the End of the Cut on a Coach Equalizer

Fig. 5—A Few Ounces of Welding Rod Save a Costly Equipment Replacement. Building Up Worn Seats in an Injector Body

The "M of E" or the maintenance of equipment falls into the category of the mechanical department and has to do with the upkeep of locomotives, tenders, passenger equipment, freight equipment, Diesel equipment and work equipment which includes wreckers, clam shells, ditchers, spreaders, pile drivers, drag lines and tractor equipment of various kinds, and the maintenance of power plants at various points on the railroad generally is maintained or comes under the jurisdiction of the mechanical department.

How should welding be controlled on these various items so as not to conflict with the various rules and regulations as designated by the Bureau of Locomotive Inspection and the A.A.R.? Every railroad should have an organization or a committee who could meet periodi-

cally to discuss welding practices and problems. They should be charged with the responsibility of not only suggesting and approving of welding practices but also be the medium through which the committee rules and standard practices be enforced. The welding committee should consist of one or two mechanical superintendents, mechanical engineer, engineer of tests, superintendent of car department or the master carbuilder, chief mechanical inspector, chief boiler inspector, the forging supervisor or general blacksmith foreman and the chief welding supervisor. Each is placed on the committee due to his particular knowledge as head of his department; for instance, if a suggestion were made at a committee meeting relative to welding some part of motion work, the chief mechanical inspector would approve or disapprove according to his interpretation and knowledge of the rules pertaining to welding on parts as defined by the Bureau of Locomotive Inspection. The same thing applies to boilers. The chief boiler inspector is there to protect his class of work and

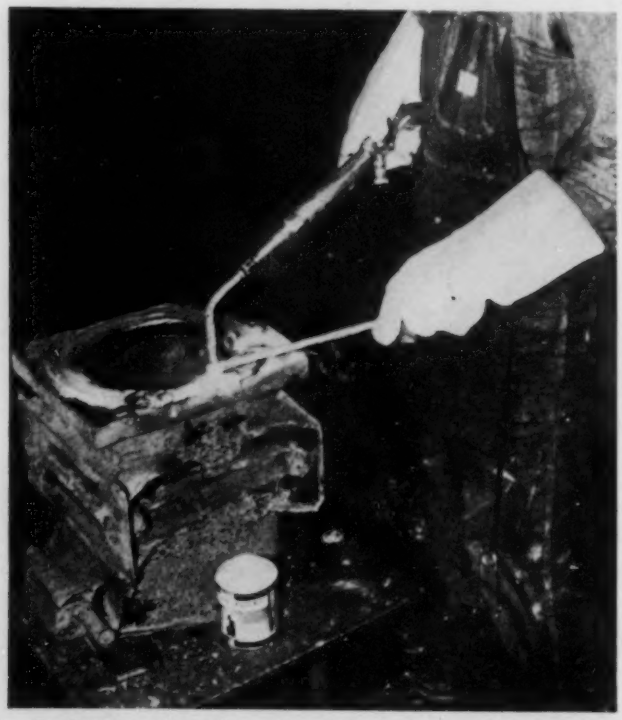


Fig. 7—Building Up a Worn Coach Journal Box with Bronze Welding Rod Restores Another Piece of Equipment to Help War Transportation

will not approve of suggestions that conflict with rules and practices that are considered necessary for a safe and suitable method of repair. The engineer of tests has knowledge of metals and is invaluable in this respect; likewise the chief mechanical engineer will advise on design from the engineer's stand-point. The forging supervisor with his knowledge of the working qualities of the various steels used and their heat treatment is a great asset to a committee of this kind. He can advise on preheat and stress-relieving temperatures and can assist greatly in formulating a procedure of welding. So with a committee of this kind you have a rich and abundant source of information and experience with which to draw from at a committee meeting.

Welding practices on all railroads are pretty much the same in that similar items are welded or reclaimed by a method of procedure to suit conditions at the point at which work is being done. A welding practice should not be permitted until it has been handled by the welding

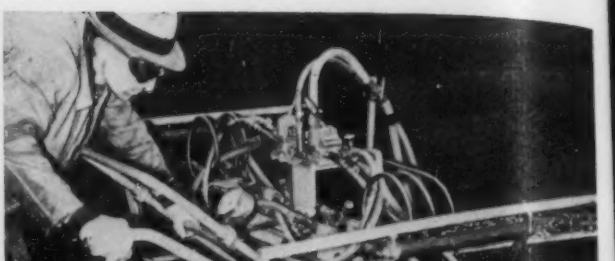


Fig. 8—Making the Rail Last Longer. Flame Hardening of Rail Ends Adds to the Life of Rail Without Use of Critical Metals

committee and approved by the chief mechanical officer. Welding practices, like mechanical standards, are the results of tests conducted to determine the best practical method of procedure to follow in order to bring to completion a safe and practical job. It would be impractical to permit all our mechanics to do the job in the way or manner he thought was best. It would likewise be insane to permit welding to be done without any method or procedure. The results would be countless engine failures. However, even though we have definite rules and procedures for the various weld-

Fig. 9—Building-up of Rail Ends in Track by Welding Postpones the Need of New Rail Purchases

ing practices the welding committee should have an open mind on the subject and be receptive to ideas and suggestions which would tend to be an improvement over present practices. The welding personnel in the shops should be encouraged to make suggestions to the end that welding will be done more safely, economically and practically.

The welding operator should undergo some type of welding test which would qualify him for the work in his particular department. The railroads of the middle west, to my knowledge, do have a qualifications test similar to the approved A.W.S. test. These tests are not given with the thought of running men off the job but to make better welding operators. At the introduction of the qualifying of welders on the Missouri Pacific it was astounding to find that men we considered good old-time operators made the poorest grades and when the news got around the psychological effect it had was more astounding than ever. The older operators wanted to be looked upon as qualified welders from a practical point and ability and later on did prove that they could qualify.

Tests were conducted semi-annually. This has been changed and eliminates a qualified welder from making further test coupons. He will make them only at the discretion of the shop superintendent, master mechanic or welding supervisor. This measure was put into effect to save precious materials and man-hours, not only on the part of the welding operator, but also of the men who prepare and finish the test coupons. It is expected that this practice will be canceled at the end of the war and revert back again to the semi-annual test.

The subject of how welding practices are originated and put into effect, together with the qualifying of the welders, has been touched upon. Materials such as welding rods and electrodes, their size and grades and amounts should have the approval of the party responsible for welding before the purchase order is made and approved, for the reason that he has a general knowledge of the welding programs in effect and programs planned months ahead. If this course is not taken sizes and grades are generally ordered that don't move fast. The results will be—when this commodity is purchased in carload lots the fast-moving size will be used leaving the larger sizes still in stock, and when you cry to the high heavens for more $^{5}/_{32}$ or $^{3}/_{16}$ in., the WPB penalizes you and points out you have so many tons of welding wire on the last invoice date and you consumption is so many tons a month, therefore, we can't approve of another request by you to purchase more welding wire. Seriously, gentlemen, this is an item which should be policed and if properly handled it will eliminate a lot of correspondence and help create a harmonious feeling between the users and they who have the authority to say whether you can or you can't purchase it.

I would like to mention at this time that the mechanical personnel of the roads I am acquainted with are very appreciative of the wonderful assistance gained from the reports and papers of the various fact-finding committees of this SOCIETY. They rely on this information and use it in their specifications for they know that the members of these various committees are very competent and are making it their vocation to the end that welding will be more generally understood and simplified so that more welding operations can be performed with the assurance of success.

Reclamation by Hard Facing*

By F. G. Jones†

HARD facing is the placing of an overlay of metal which is inherently hard and wear resistant or corrosion resistant, on a metal part not possessing these qualities, or on a part possessing these qualities but worn or corroded to the point where it may be unserviceable. This overlay is usually applied to the part by welding, either by oxyacetylene welding, metal arc welding, carbon arc welding or furnace welding.

Oxyacetylene welding of a hard facing overlay material is usually done with a standard oxyacetylene welding outfit, although some manufacturers of welding equipment have designed special tips for applying hard facings. Oxyacetylene welding is generally used when applying the non-ferrous hard facings. Metal arc welding is used when applying most ferrous base hard facings, although the non-ferrous hard facings have been applied in this manner in cases where the part to be hard faced was of such size or shape as to be unusually difficult to hard face by the oxyacetylene process. Carbon arc welding is used on some types of hard facings which are supplied in paste or powder form. These hard facings are spread on the part to be hard faced and fused into the part with the carbon arc. This method, in reality, forms an alloy of the hard facing particles and the base metal. This method is usually used where the part which is hard faced can be placed in service in the "as-welded" condition. The various methods of furnace welding or furnace brazing have been found more suitable for applying hard facings to small parts, or to large quantities of duplicate parts. In this method a casting of hard facing metal is bonded directly to the part to be hard faced, if the alloy lends itself to this method, or the casting of hard facing metal is bonded to the part by low-temperature brazing or copper brazing. The method of application of the hard facing overlay must be determined from the type of hard facing to be used, and the size and number of pieces to be hard faced. Very large parts have been successfully hard faced by the oxyacetylene process when properly prepared and handled.

Hard facing materials are manufactured in several types and grades. The various types are manufactured for wear resistance, corrosion resistance, impact resistance, resistance to erosion, or combinations of these qualities. The proper type must be chosen so that it will perform the service required. The various grades are manufactured to suit conditions under which the hard facing overlay must be put in condition for use. In most cases, the hardest possible grade is chosen, if it meets the requirements as to type. Usually, these hard grades must be ground. If the part to be hard faced is such a

* To be presented at the Annual Meeting, A.W.S., Chicago, Ill., Oct. 18 to 21, 1943.

† Wall-Colmonoy Corp., Chicago, Ill.

shape or size that it is not practical to grind it, then a softer grade, which can be machined, should be chosen. In most cases, the oxyacetylene deposited non-ferrous hard facings offer a greater choice along this line.

The various types of hard facings are alloyed in their various combinations for definite reasons. The non-ferrous alloys, such as the chromium-boron-nickel alloy, or the chromium-tungsten-cobalt alloy, are designed for corrosion and wear resistance, and resistance to erosion at high temperatures. The ferrous base hard facings seem to be less suitable for high-temperature operations, but have definite advantages, in most cases, where there are severe impacts, or a succession of milder impacts along with abrasion.

Serious consideration should also be given to hard facing of new parts, especially under the present conditions. Many times a new part is designed of an alloy steel, in order to harden the part, or a portion of it, to resist wear or abrasion. If it were designed for hard facing, the part often can be plain carbon steel, hard faced where the wear occurs. New parts which are hard faced usually outwear a hardened steel part many times, and also use less of the now so urgently needed strategic raw materials.

The essential use for hard facings, under the present emergency, is to save our supply of strategic elements. Some of the hard facings available use no strategic raw materials whatever, and serious consideration should be given to the possibilities of using these materials.

As an example of the value of hard facing methods for reclamation purposes, one machine part which must remain unnamed, but weighed 46 lb., required only $2^1/_2$ lb. of non-ferrous hard facing material to reclaim it, applied by the oxyacetylene process. It required 183 lb. of rolled alloy steel plate to produce a new part.

Other examples of the saving of strategic alloys are as follows: forming rolls, forming $^1/_4$-in. thick hot-rolled steel plate, were made of oil hardening tool steel, hardened to 65 Rockwell "C." These rolls were hardened in an attempt to prevent wear, but there was considerable breakage. These worn and broken forming rolls were reclaimed with a non-ferrous hard facing alloy, of only 40 Rockwell "C" in hardness. These hard-faced rolls have operated as long as the hardened steel, with no breakage. The 40 Rockwell "C" material made it possible to machine the reclaimed rolls. The reclamation required from 4 to 6 lb. of hard facing alloy, whereas it required about 70 lb. of tool steel to make a new roll.

Another example of the reclamation made possible by hard facing, is the reclamation of hammer mill hammers. In one case, hammers pulverizing an asbestos product, were made of hardened high-speed steel. This material would operate successfully for three months. These hammers were hard faced with ferrous base hard facing, applied by oxyacetylene welding. The reclaimed hammers lasted 6 mo. The few pounds of hard facing saves many times its weight in high-speed steel, which certainly is strategic at the present time.

Another example of the reclamation of hammers for hammer mills, is that of 39 manganese steel hammers. These hammers were hard faced with 6 lb. of a paste form of hard facing material, applied by the carbon arc process. These hammers were then maintained in good condition by applying $1^1/_2$ lb. of the same material, 15 applications in all. The hard faced hammers crushed 158,000 tons of cement rock. The hammers, when not hard faced, would only crush 77,000 tons. The paste hard facing used in this case contains no strategic material.

One example of the value of hard facing new parts, is that of induced draft boiler feed fans. These fans, when made of alloy steel plate, would operate about 4 mo. A paste type hard facing, applied by carbon arc, increased the life of these fans to 17 mo. The hard-faced fans were plain construction or boiler plate, and the paste type hard facing contained no strategic material.

An example of the use of corrosion-resistant and wear-resistant hard facing is in the use of large cock valves used in corrosive solutions in oil refining. Corrosion-resistant steel valves required relapping, to seal them so they would shut off, every 6 mo. The same type valves, hard faced with a non-ferrous hard facing alloy by the oxyacetylene process, have been in operation over 18 mo. without relapping. The original corrosion-resistant steel valves are now to be reclaimed with the same hard facing material.

Turbine type pumps, made of corrosion-resistant iron alloys, used in coke by-products plants, have been reclaimed with a non-ferrous hard facing alloy by the oxyacetylene process, and the reclaimed pumps last more than three times as long as they did originally.

Draw dies 15 in. O.D. x $7^3/_4$ in. I.D. x $3^1/_{32}$ in. thick, were hard faced with 14 lb. of non-ferrous hard facing in 9 hr. by oxyacetylene welding. These dies are heated to 400° and a very thin layer of hard facing material applied, known as a tinning coat. The dies are then heated to 1200° F. The welding progresses, building up the hard facing so that it will finish $^3/_{16}$ in. thick. If the die cools below a visible red heat, the welding is stopped, and the die reheated to 1200° F. Before hard facing, hardened tool steel dies lasted only 30 days, and the dies had to be repolished every day. After hard facing, the dies ran 30 days before repolishing. A hard faced die put in operation Dec. 15, 1942, was still operating on Aug. 3, 1943.

Another example of the savings made possible by hard facing, is that of a large automobile fender die which was altered at the change of models by the use of a machinable grade non-ferrous hard facing. This die was built up at one point approximately 2 in. thick. This build-up tapered off to nothing about 2 ft. each way. About 50 lb. of hard facing was required to do this job, and this saved a new 3000-lb. casting of alloy cast iron, all the machining and the alteration of the pattern, if not a new pattern.

Machine parts, used in the production of war material, can be reclaimed very easily. In one case, a high-speed lathe center was being reground each day. This center, when worn, was hard faced and ground at a cost of $2.00. After hard facing, it needed to be reground only every 21 days. This was a No. 3 Morse Center.

The main requirements of a hard facing seem to be that it must have a low coefficient of friction, it must not flow under pressure or impact and a low coefficient of expansion is desirable. It need not possess work hardenability, although for some uses this is quite desirable. It should also have a very high resistance to galling against itself or against other materials.

Many parts, other than those listed above, can be reclaimed at a cost not higher than a new part, with the advantage of the additional life, and it seems quite urgent, during the present emergency, that each and every user of machine parts do his best to save strategic materials by the use of hard facings.

Locomotive Parts Fabrication and Welding of Bronze Bearing Surfaces*

By J. W. Kenefic†

WHEN the national emergency period first descended upon American industry it created an unusually pressing problem for the railroads. They, more than almost any other industry, have a constant maintenance problem of large proportions. To keep locomotives and rolling stock operating efficiently and with a wide margin of safety requires frequent repairing and replacement of numerous parts. To complicate the position of the railroads even further, they were for a time handicapped by a comparatively low priority position, which made it doubly difficult to obtain replacement parts through the customary channels.

Because of these factors the railroads found it necessary to embark on an extensive program of fabricating their own replacement parts on the one hand, and of rebuilding or reclaiming worn-out parts on the other. Much of this work was, at that time, quite new and untried. It can be said now, with great credit to railroad shop personnel, that they coped with these problems in a very progressive manner. They have applied welding, brazing and other oxyacetylene processes in maintenance work in such ways as to create not merely acceptable substitutes for standard parts, but often an improved part—lighter, stronger or more durable than the original.

So numerous is the variety of parts which can and have been fabricated or reclaimed by welding that it will be impossible to give details here on more than a few. For the most part these will be confined to locomotive parts. One railroad has compiled a list of 350 locomotive parts, to determine how many could be made by flame cutting and welding. This list was divided into four classifications: first, parts which are more economical to fabricate than to purchase; second, parts whose cost of fabrication in the shop is equal to outside purchase price; third, parts which cannot be obtained except by shop fabrication; and fourth, parts not to be considered. It was found that about 90% of the parts fell into the first three groups, that is, either through necessity or economy it was desirable to fabricate these parts by welding.

In addition to fabrication of new parts there is considerable activity in repairing of cracked or broken castings, as well as restoration of worn areas or moving parts by means of building up these surfaces with steel or bronze weld deposits. A number of such applications will be described and illustrated.

Lead-Bronze Welding Rod

Bronze bearing metals for electric arc application on certain wearing surfaces on locomotive parts were introduced to the railroads six or seven years ago. Since then the merits of these applications have been proved many times over. The operations described in this article have all been in use for a year or more, and are accepted as standard practice. Other applications are in the process of being tested and as soon as they are proved worth while they, too, will be accepted as standard operations.

The bronze weld metal used for these purposes is of a type developed specifically for giving a satisfactory bearing surface for those parts of the locomotive, such as driving box laterals and crowns, which are subjected to unusually severe service conditions. This self-fluxing, lead-bronze electrode is particularly suited as a bearing metal because of its high lead and tin content. It is of substantially the same analysis as the brass which is customarily poured in on driving box laterals.

This bronze can be applied with a carbon arc or by the

Fig. 1—Building Up a Driving Box Lateral by Metallic Arc Welding with Self-Fluxing Lead-Bronze Bearing Metal

* To be presented at the Annual Meeting, A.W.S., Chicago, Ill., Oct. 18 to 21, 1943.

† Superintendent, Railroad Service, Western Division, Air Reduction Sales Co.

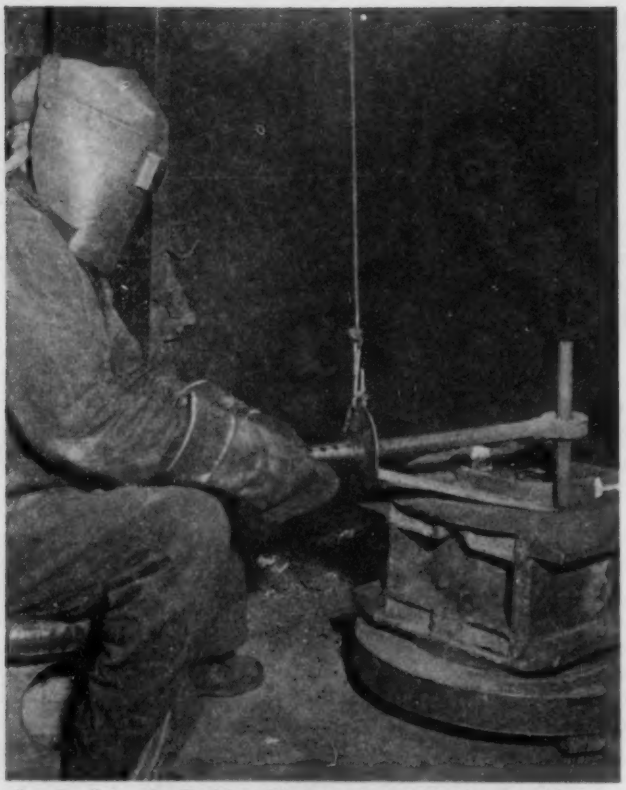


Fig. 2—Setup for Building Up Lateral with Carbon Arc Method. Driving Box Rests on Rotating Platform

metallic arc method. In either case the current should be adjusted to assure good penetration. This is important because the particular advantage of weld-deposited laterals over poured-on laterals is that they do not become loose. Experience shows that operators who are at all familiar with arc welding have no difficulty in learning this operation. They do not have to go through a long period of training to master the application of this bronze.

There are a number of significant advantages in this process. Foremost among these is the complete elimination of loose laterals on driving boxes, and the excessive locomotive maintenance costs which often resulted from the premature need for replacing a loose lateral. Maintenance of welded laterals requires only the addition of a few pounds of weld metal to replace that which has worn away, instead of replacing the entire bearing as is necessary with a poured-on base.

Another advantage is the reduction of the large tonnage of critical bronze necessary to keep locomotives in operating condition. For example, laterals on new boxes can be built up with about 50% of the bronze which would be required for a poured-on surface. The reason for this is, of course, the elimination of the dovetail which is required to hold cast liners in place.

Other operations which will be described are the reclamation of crown brasses by building up, the elimination of pressed-in crowns, building up with bronze on fabricated shoes and wedges and several other applications.

Building Up Laterals

The most important application of this rod is, however, on building up laterals. Here the situation is somewhat different according to whether the driving box is an old one, or a new one, without dovetail. On old boxes the entire dovetail space can be filled with a ring-shaped steel plate, flame cut to shape and welded into place as a foundation for the bronze overlay. Or, the cavity can be filled completely with bronze weld metal. In either case the best results are obtained with the crown brass removed before applying the lateral.

Figure 1 shows the method of applying bronze by the metallic arc method, showing also the metal form made of $1^1/_8$- x $^1/_8$-in. band iron tack welded in place to confine the weld to the desired shape. A dam of wet asbestos can also be used for this purpose. The box is mounted on a rotating table driven by an air motor. A 400-amp. welder is used, with $^7/_{16}$-in. bronze rod. The deposit is built up to a height of at least $^1/_2$ inch, taking care to make the deposit as smooth and regular as possible to avoid pits or depressions after machining.

The same operation performed with the carbon arc is illustrated in Fig. 2. A water-cooled carbon holder is used and the box is set on a floor-height table which revolves on ball bearings. A suitable fume collector was built for this job. Figure 3 shows the box after machining.

On new boxes it is possible to make a greater saving than on old boxes since there is little preparation required before putting on the original coating of bronze. On new boxes it is necessary only to have an absolutely clean surface to receive the welded lateral. Some shops may wish to undercut the box $^1/_{16}$ or $^1/_8$ in. to compensate for the mixing of steel with bronze on the first pass, but the same effect can be secured by building up this additional height on the lateral itself.

After the driving boxes have been in service and it becomes necessary to build up the lateral again, all that is needed is to weld sufficient metal over the old bronze to restore it to its original height. There is no problem of laterals becoming loose. This method is considered the only economical way of maintaining driving box laterals today.

Cast-iron engine truck boxes may be prepared in somewhat the same manner, except that a light foundation deposit of a harder bronze (substantially 60% copper, 40% zinc) is first laid down by oxyacetylene welding, as shown in Fig. 4. This type of bronze tins vary readily with the cast iron. For this base deposit a $^1/_8$-in. allowance was made on the box. The lead-bronze bearing metal was then deposited as shown in Fig. 5, by arc welding over this first layer. Subsequent restorations of the worn lateral are made without repeating the oxyacetylene operation.

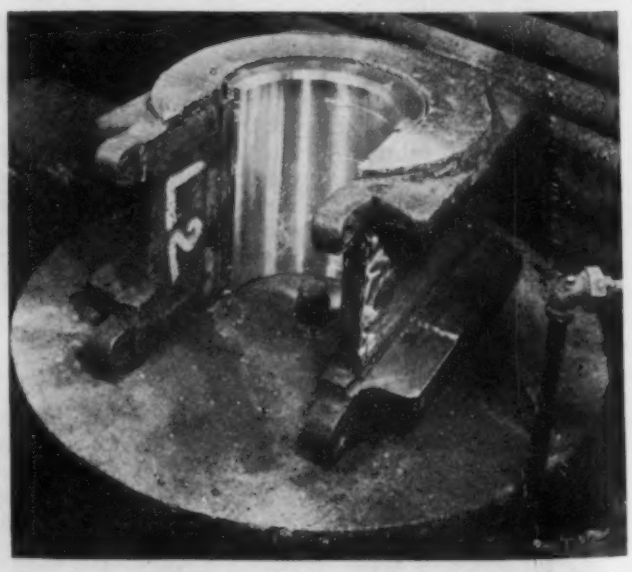


Fig. 3—Finished Machined Lateral, Metallic Arc Welded with Lead Bronze

Crown Brass

The reclamation or replacement of crown brasses offers another application of the bearing bronze. If the brass is not loose in the box it can be built up in this position, being very careful to control the heat. More often, however, the crown is removed from the box and built up as shown in Fig. 6, where the piece is held in position by a rotating fixture. Bronze is built up on the back and the face of the crown, for a distance of 4 or 5 in. from the toe edges. The appearance of the crown after welding is illustrated in Fig. 7, which shows three crowns, and also two back end main rod brasses. After welding, it is good practice to return each crown brass to the same box it was removed from.

Shoes, Wedges and Other Parts

Elsewhere in this paper, mention is made of the fabrication of driving box shoes and wedges, with an overlay of bronze. The same operation can be done on cast steel, cast iron and bronze shoes and wedges, using a small size rod to prevent warping of the cast part.

If desired, the bronze facing can be applied to the shoe and wedge side of the driving box itself. No special preparation is necessary as in the case of a poured-on surface, and when the box is removed from service for resurfacing it is only necessary to add sufficient bronze to bring it back to size. On new boxes no special preparation is required. Figure 8 shows a group of new boxes built up on the shoe and wedge side, and Fig. 9 shows the appearance of the surface after machining.

A fabricated trailer truck lateral plate is shown in Fig. 10. This $^{7}/_{8}$-in. plate, built up with 10 lb. of lead bronze, replaces bronze liner weighing approximately 70 lb. By bolting this plate to the trailer box the lateral is transferred to the end of the axle instead of being placed at the hub of the wheel. This method saves considerable bronze and gives better service than the conventional liner.

Fig. 4

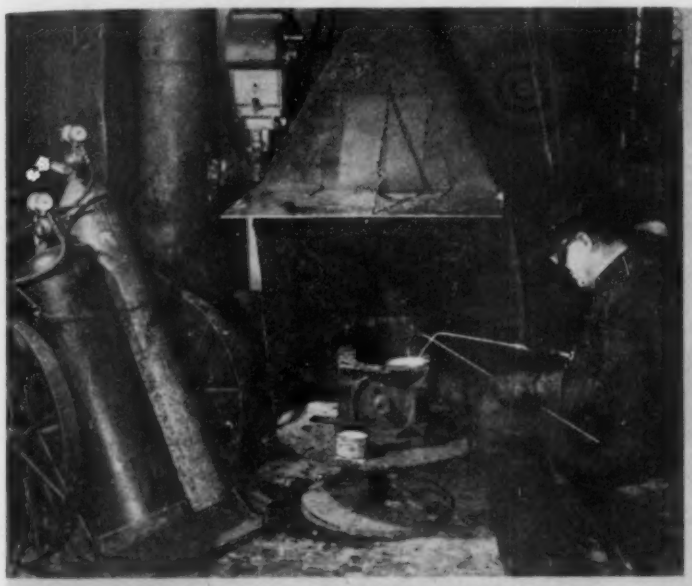


Fig. 5

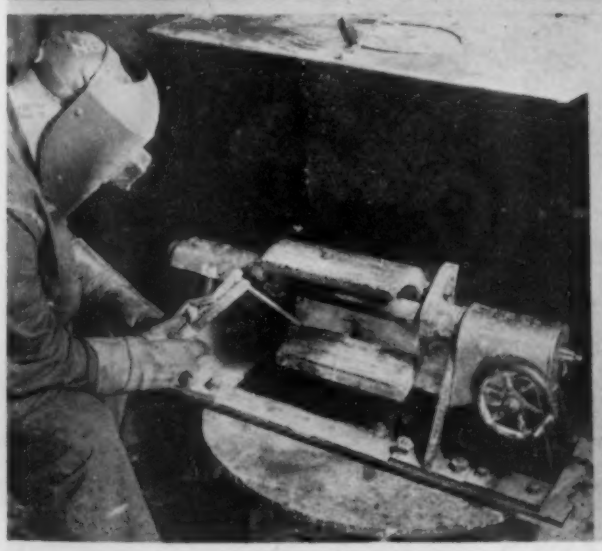


Fig. 6

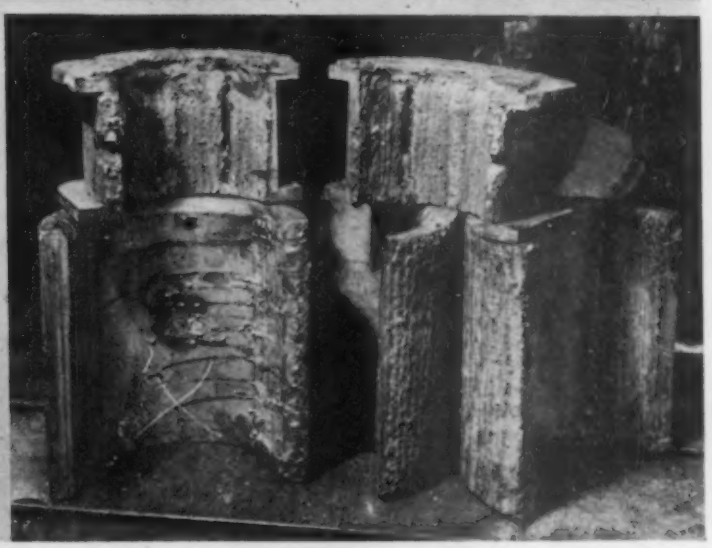


Fig. 7

Fig. 4—This Cast-Iron Engine Truck Box Receives a Light Initial Deposit of 60–40 Bronze, Welded by Oxyacetylene, Before the Bearing Metal Is Arc Welded On

Fig. 5—The Same Box Shown in Fig. 4 Is Here Being Built Up Over the Oxyacetylene Deposit with Lead Bronze

Fig. 6—Restoring Worn Surfaces on Cast Crown Brass. Rotating Positioner Facilitates the Work

Fig. 7—Group of Crown and Back End Main Rod Brasses After Building Up with Bronze Weld Metal

Among other applications of the lead-bronze rod is the surfacing of fabricated cross head shoes. A small size rod should be used on this operation to prevent warpage. Very good results have been obtained with such cross-head shoes, running on flame-hardened guides.

Fabricated Driving Boxes

Several years ago a railroad shop experimented with the fabrication of driving boxes by cutting a single piece from a solid billet, using a cutting torch for the rough cut and then machining to size. Since an excessive amount of machining was necessary, the design was changed to the three-piece construction shown in Fig. 11. A center section and two side pieces are flame cut, beveled and welded together. After stress relieving, the welded box is machined on the crown surface and on the side, for application of crown brass and liner. The crown brass is then put in as a weld deposit, building up sufficiently to allow a depth of $^{3}/_{4}$ in. after machining. As shown in Fig. 12, spreaders are used to prevent the box from pulling in at the cellar fit during welding. The crown brass is machined, serrated and the bearing

Fig. 8

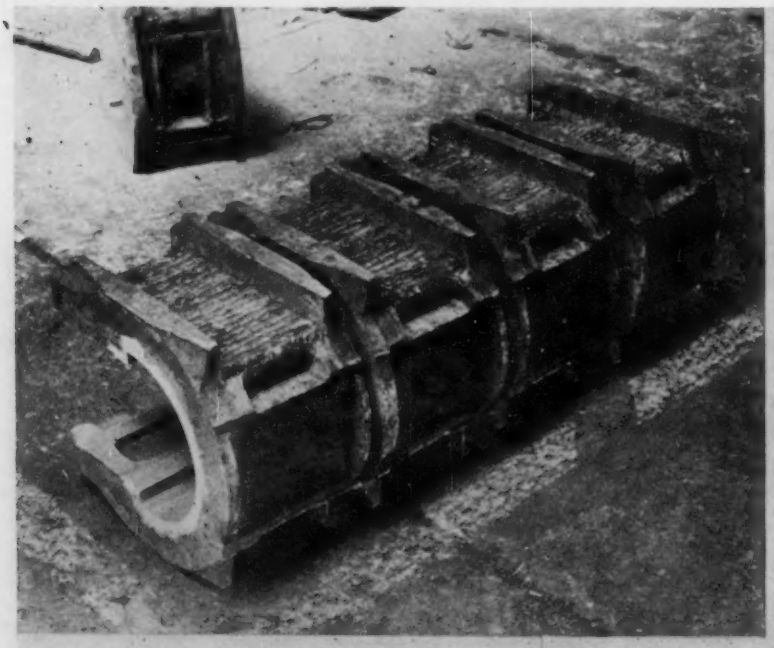


Fig. 9

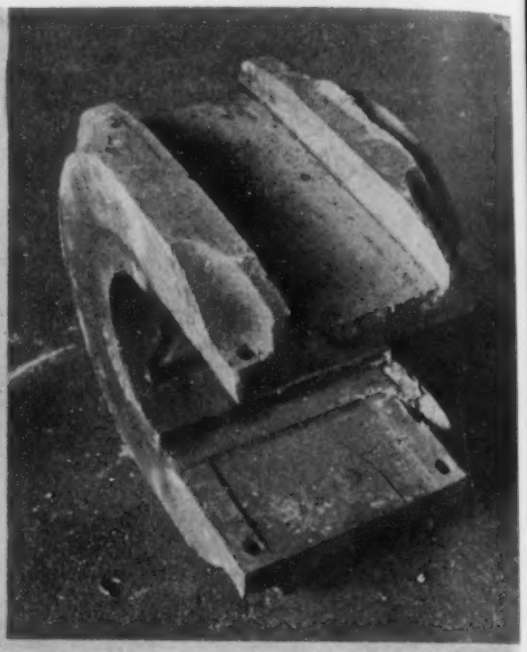


Fig. 10

Fig. 11

Fig. 8—Locomotive Driving Boxes Built Up on Side Which Bears Against Shoe and Wedge. Bearing Bronze Is Used Here

Fig. 9—Appearance of Built-Up Side of Box Shown in Fig. 8 After Machining of Bronze Overlay

Fig. 10—This Fabricated Trailer Truck Lateral Plate with Bronze-Welded Bearing, Replaces a 70-Lb. Bronze Liner

Fig. 11—Fabricated Driving Box, Made of Two Side Pieces and a Center Piece Welded Together

metal is then poured in on crown and lateral face. The final operation, the finishing off of the babbitt bearing surface, leaves the driving box as shown in Fig. 13.

This method of fabricating requires only 38 lb. of brass in the welded crown, as compared with 200 lb. for a rough cast crown brass.*

One railroad has adopted a practice for reclaiming piston head spiders. The taper bore is built up by welding and machined to fit the piston rod. A light cut is also made on the piston rod to assure a perfect fit. To reclaim these parts, welding and machining costs total about $9, compared to a total purchase price of almost $50 for a new piston rod and spider. This shop also finds that labor time for fitting and connecting the piston to the crosshead is reduced by 75%, enabling them to get the engine rolling again in much less time.

* A method which has proved successful in reclaiming worn driving boxes from switch engines, though not recommended for passenger locomotives, is to press out the cast brass and weld in a forged steel filler piece, leaving space for a 5/8-inch layer of manganese bronze. The box is preheated, and the bronze is applied with an oxyacetylene torch. After the brazing, the box is stress relieved and allowed to cool slowly before machining.

Fig. 12—Fabricated Driving Box with Crown Brass Welded in

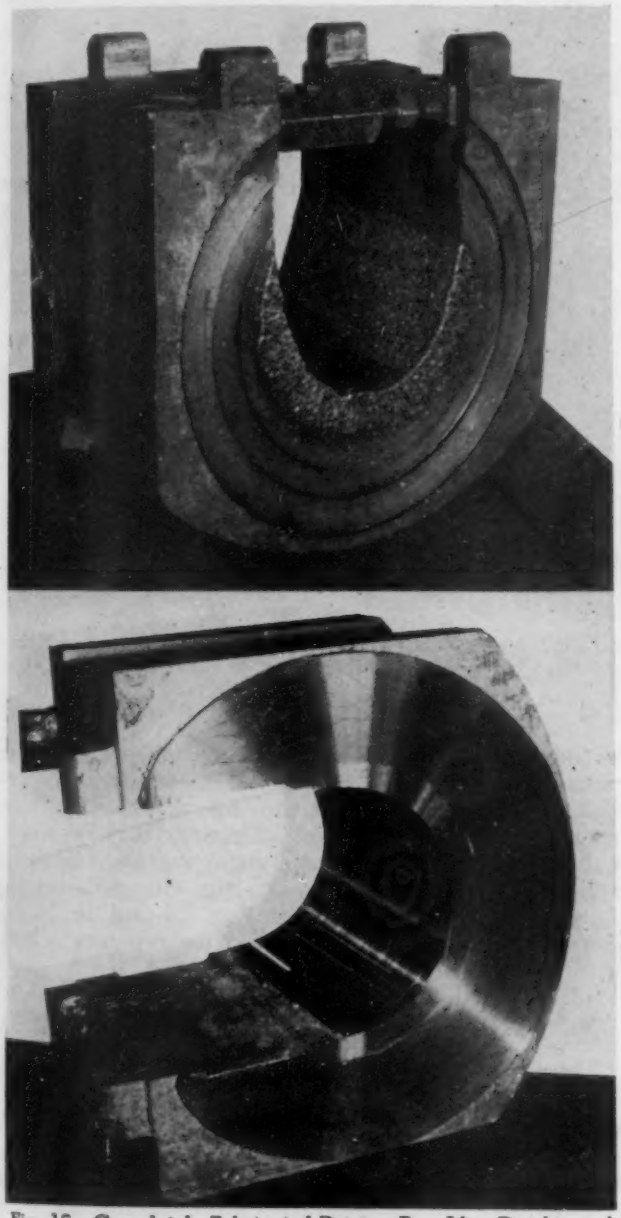


Fig. 13—Completely Fabricated Driving Box After Finishing of Babbitt Metal

Another interesting and economical operation of a somewhat different sort is the reclamation of malleable firebox grates. Burned-out grates are salvaged by breaking off the good end and welding it to the good section of another grate. Arc welding is employed for this operation, using cast-iron electrodes. There are 515 firebox grate units in each locomotive, costing originally $1.02 each. The welding cost is approximately 10 cents per grate, or $51.50 for a complete set of grates. Thus the theoretical saving over new grates is $473, discounting entirely the possibility of securing new grates when needed.

Overlaying with Steel

There are a number of parts which, when they become worn, are built up to original size with steel weld metal. Coal stoker screws are a typical example of this. The restoration is made every time the locomotive is overhauled, since a built-up screw usually lasts from shopping to shopping. As shown in Fig. 14 the stoker screw is built up by arc welding, in this case with the screw mounted horizontally. If the screw shows a tendency to warp when mounted in this position, such warpage can usually be eliminated by doing the work with the screw supported vertically. For this operation an electrode conforming to AWS Classification E 6012 should be used, allowing good control of weld metal in bridging gaps.

It is customary practice on many roads to build up the worn surfaces on brake head pieces, by arc welding with steel electrodes. This again is a restoration which can be made repeatedly. The brake head is mounted on a simple, counterbalanced welding positioner, and the deposits are made on the pads which bear against the brake shoe.

Two building-up operations involving the use of bronze weld metal other than bearing bronze are illustrated in Figs. 15 and 16. The first is the restoration of the circumferential wearing surfaces of a locomotive water pump piston. Note that oxyacetylene welding is used for applying the bronze. The second illustration shows the reclamation of a crosshead shoe of the Hunt-Spiller type. The inner surface is built up with 60–40 bronze, using an oxyacetylene torch. A flexible-hose fume collector is positioned close by to carry off the fumes which are given off by the bronze.

A number of other parts which have been built up by welding or worn surfaces are shown in Fig. 17. These parts, all regularly reclaimed by this method, include freight and passenger car brake heads, a brake hanger, lock lifter, locking block and a knuckle piece.

Repairing Castings

A welding operation of a different character is the gouging and filling of cracks in castings. Since it is no longer possible to obtain replacement castings at the drop of an order blank, this operation has become widespread among the railroads. Certain cast parts particularly are subject to service conditions, such as the couplers between cars. The constant pounding of a railroad train upon the tracks also promotes the formation of cracks in other parts, such as car pedestals, truck castings, coupler yokes and brake beams.

Cracks in these castings are eliminated by first gouging out the metal surrounding the crack, then filling in the resulting space with weld metal. The initial gouging

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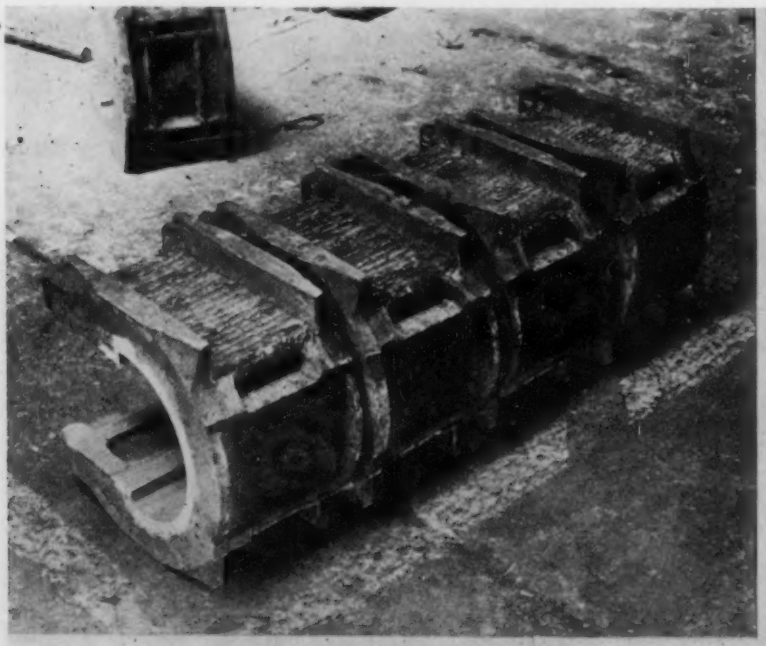


Fig. 9

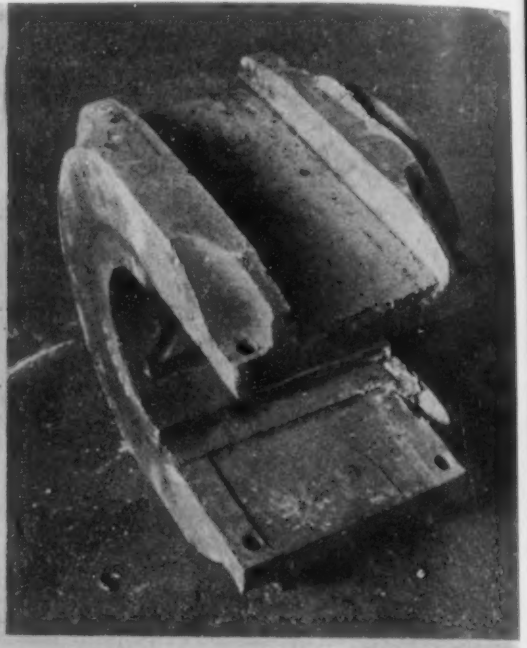
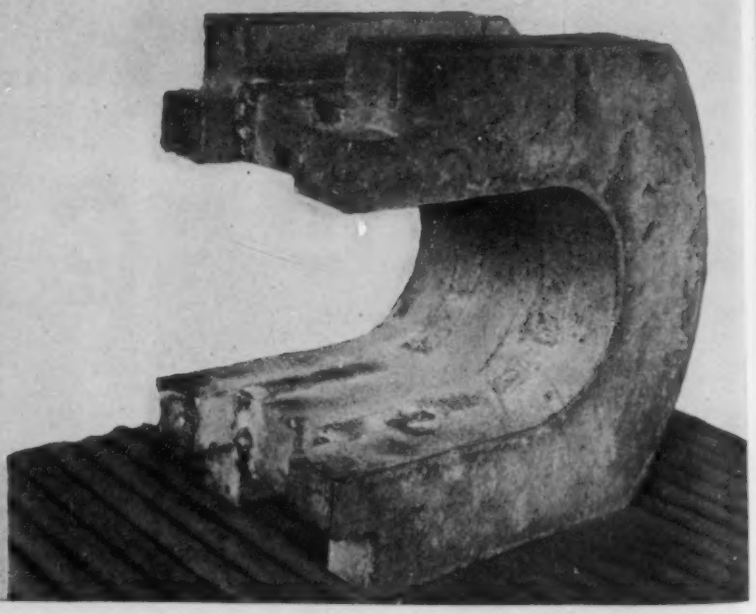


Fig. 10



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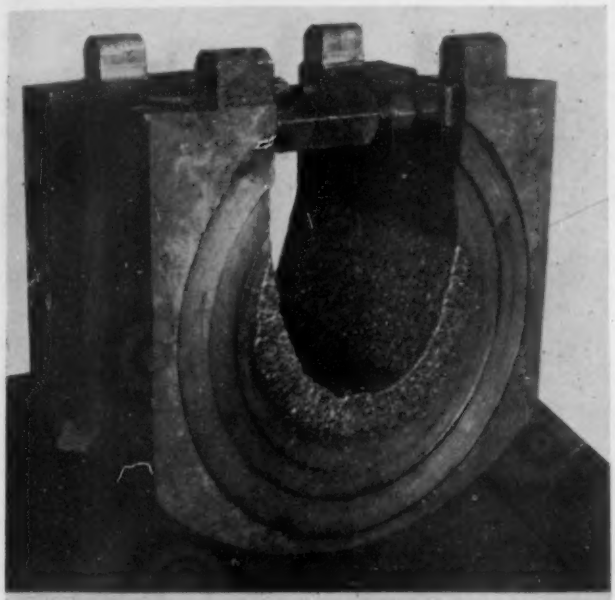

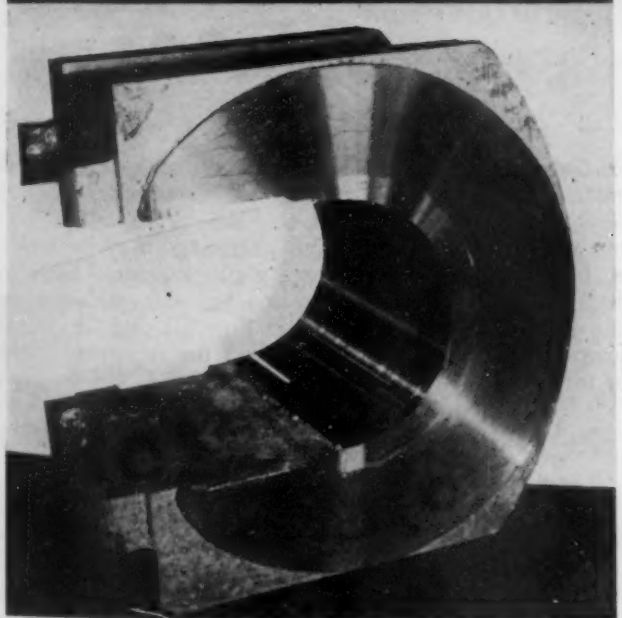

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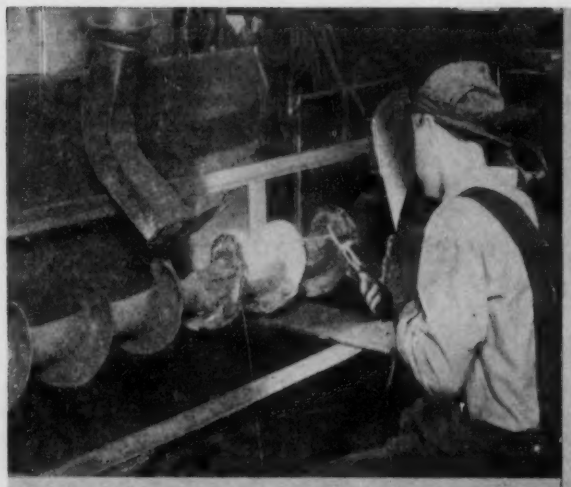
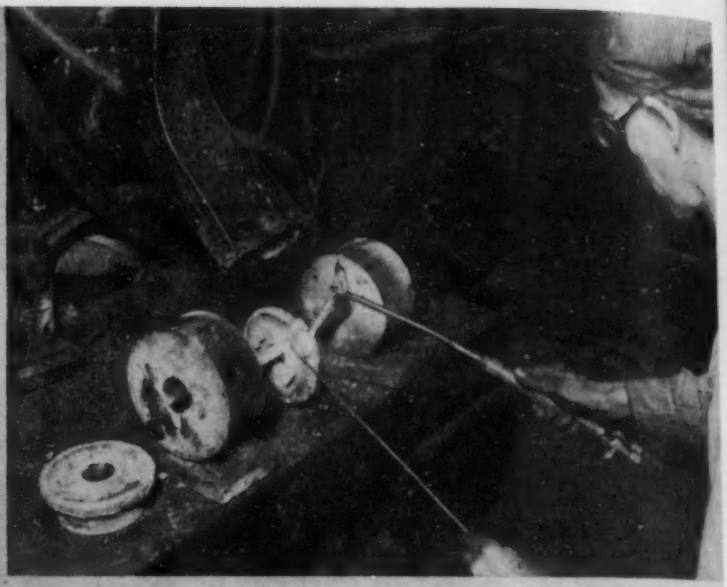
Fig. 14

Fig. 15





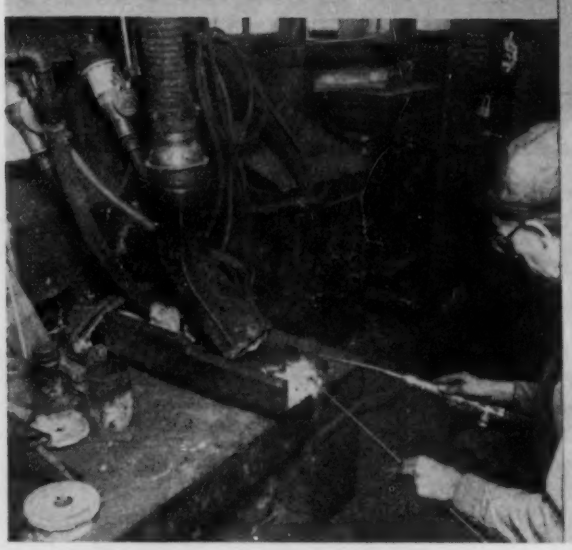


Fig. 16

Fig. 17

Fig. 14—Stoker Screws Wear Down Constantly, and Are Restored to Original Dimensions with Steel Electrode

Fig. 15—Outside Surface of Locomotive Water Pump Piston Is Here Being Built Up with Bronze

Fig. 16—Wearing Surface of Hunt-Spiller Crosshead Shoe Is Built Up with 60–40 Bronze, Deposited by Oxyacetylene Welding

Fig. 17—Brake Heads and Hangers, Lock Lifter, Locking Block and Knuckle Pieces Are Among Other Parts Regularly Reclaimed by Weld Build-Up

operation is done with a hand torch. Figure 18 shows gouging of heavy bumping cracks in a coupler face. The operator burns away metal on both sides of the crack, judging the proper depth of gouge by the final disappearance of the dark red streak in the center of the burning reaction. Such a streak is caused by the presence of the crack.

Welding to fill the trough of the gouge is done by the metallic arc method. An electrode conforming to specification E 6010 should be used here, to secure high ductility in the weld.

Figure 19 shows a number of couplers before and after repairs. Those on the left have been built up on the end or on the shoulder, while those on the center and right have been gouged preparatory to welding. The coupler on the extreme right has had both types of repairs made. Cracks in the center have been welded and the lip has been built up with steel weld metal.

Another example of gouging to remove cracks from castings is illustrated in Fig. 20, showing a truck side casting. This part is furnace annealed after the weld repairs are completed. In this case welding was done by the electric arc method. Castings may be welded with success by the oxyacetylene method, however, and two examples of this are the car pedestal and the journal boxes illustrated in Figs. 21 and 22. Cast-iron welding rod is recommended for repairing cracks or for building up on such castings.

Conclusion

It is evident to anyone concerned with maintenance of motive power that the applications of welding developed in the last few years are playing an essential role in keeping the locomotives rolling. Equipment shortages lie at the root of the transportation problem, and the situation as it affects locomotives can be seen from the fact

that only 850 new locomotives will be built in 1943. This number hardly compensates for normal retirements from the nation's stock of 41,000 active locomotives, let alone handling enormous wartime increases in freight and passenger movements. This means that equipment maintenance and repair are of paramount importance, and will remain so as long as material shortages prevent increased construction of new motive power.

Fig. 18—Flame Gouging to Remove a Crack in a Coupler Casting. The Resulting Groove Is Then Filled Up By Arc Welding

Fig. 19—These Couplers Show the Range of Repairs Made on Such Castings. Note Gouges, Welds and Weld Build-Ups

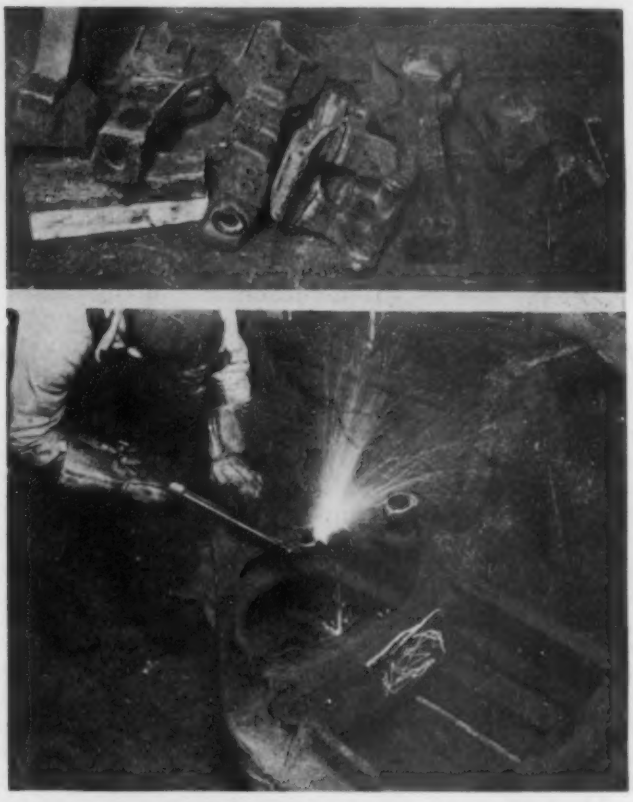


Fig. 20—Cracked Truck Side Castings May Also Be Repaired By Gouging and Filling with Weld Metal, Then Annealing

Fig. 21—Building Up a Cast-Iron Car Pedestal with Cast-Iron Gas-Welding Rod

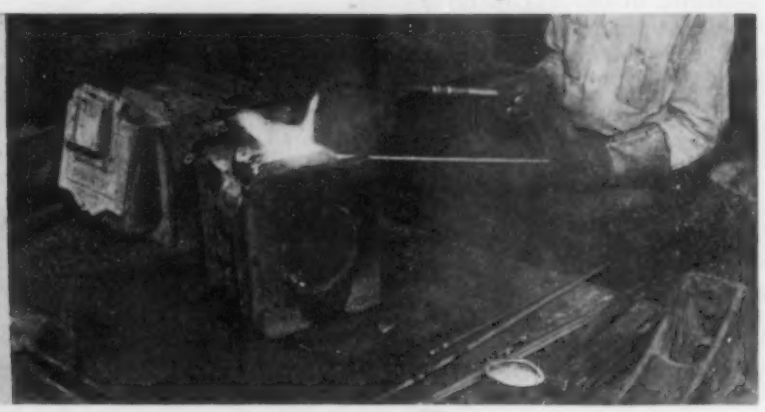


Fig. 22—Journal Boxes Are Also Repaired by Cast-Iron Welding of Cracks, Breaks or Worn Surfaces

Welding Operator Training*

By Arthur N. Kugler†

Introduction

THE production of war materiel so necessary to the actual combat operations has focused the public eye on one production process—welding. It is doubtful if the average layman of five years ago had the slightest conception of welding or even what a welding operator looked like. Today welding is so commonplace that we find our contemporary humorists using it in their jokes, in newspaper advertising featuring the latest styles for "women welders" and in contests to determine the "best woman welder."

Such a rise to prominence in the public mind is the result of many factors, probably the most important of which has been the tremendous value of the welding processes in enabling this country to produce war materiel in vast quantities, on time or ahead of schedule. Another element is the fact that a far greater number of people have become more or less familiar with the welding processes, either by actual contact as operators or through close association with someone who is welding. It is this latter fact—the greatly increased number of welding operators—that has created one of the major problems in the war of production, i.e., the training of welding operators.

The problems surrounding the training of a large number of welding operators have been too many and too varied to be covered completely in a paper such as this. Rather than attempt to treat all of these phases in a superficial manner, it has been decided to discuss, first, the basic principles of welding operator training as set forth in the several AMERICAN WELDING SOCIETY CODES on this subject issued or in preparation and second, to consider the actual operation of a course currently offered and conforming to one of these codes.

It is not necessary to know how many welding operators we have today as compared to, say, 1938. Reference merely to the relative productions of filler metals in these years is sufficient to convince the most skeptical of the prodigious proportions of the problem. Without attempting to give exact production figures, which might be of value to the enemy, it may be stated that the production of 1943 will be 10 to 12 times as great as in 1938. Since there is a fairly accurate and constant value in the quantity of electrodes each operator uses, it will be seen that it has been necessary to train 10 to 12 times as many operators as were available in 1938.

Code for Welding Operator Training

The greater part of this training was done in 1941 and 1942, throwing a large burden on established welding schools. This demand for welding training soon attracted many to the field and led to the inauguration of new schools. Unfortunately, not all entering the field had the knowledge and desire to establish schools offering adequate courses. This resulted in courses of varying content and at widely differing tuition prices. Further, intensive advertising over the radio and in the press attracted many candidates to these schools. The appeal was almost invariably worded to infer a short course at sometimes ridiculously low figures; it was always alleged that the course would produce a fully qualified operator. In some instances conditions were so bad that to all intents and purposes "price wars" existed between schools.

Added to this condition was the fact that instruction was not always of a caliber commensurate with the requirements. Two reasons may be offered in explanation of this: First, virtually all competent operators were employed in war production at high rates of pay and were, therefore, not available for teaching. Second, the remuneration offered for this teaching was unusually low compared to industrial wages, with the inevitable result—poor quality teaching.

It should be appreciated that during this period the old established schools teaching welding attempted to continue their good work as in the past. However, conditions rapidly worsened to the point where they were confronted with the choice between shutting their doors or lowering their standards. Both public and private vocational schools alike faced this situation.

These shortcomings together with what might be termed abuses led to the formation of the AMERICAN WELDING SOCIETY'S Committee on Minimum Requirements of Instructions for Welding Operators in Trade Schools. The function of this committee was and is the preparation of a series of codes for governing the operation of welding schools in the several branches of the welding art. The personnel of this committee has been drawn from many sources representing, as nearly as possible, all angles of the vocational education picture. Federal and state educators as well as representatives of schools of higher learning are members; public and private vocational schools have a voice in the proceedings; and, finally, the users of welded construction are included in the membership. In addition the committee has called upon various outside authorities for guidance and help in the preparation of specific codes.

The original tentative program provided for the issuance of separate codes, one on arc welding of steel in the larger thicknesses and another on arc welding light gage steel. Oxyacetylene was to be handled similarly with other phases to be taken up when these were completed. Subsequent developments necessitated a further subdivision of these headings, but in general this program has been followed.

The first Code was issued July 20, 1942, under the title, "Code of Minimum Requirements for Instruction of Welding Operators—Part A—Arc Welding of Steel $^{3}/_{16}$ to $^{3}/_{4}$ In. Thick (Tentative)." Obviously this Code covers the field of instruction into which the training of shipyard workers falls, although other welding training

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for pipe, structural and plate work would also be encompassed. This group was selected for the reason that the bulk of trainees were in this class.

Part A of this Code had been out but a few months when reports were received that it was too restrictive and therefore inoperable. Specific objections were raised to the minimum hours stipulated, the requirement for separate instruction in related welding information (related theory) and the clauses pertaining to size and number of arc-welding machines. Other minor objections were voiced, but the above three seemed to be the principal causes for complaint.

It should be appreciated that this Code was adopted by many states to control the welding schools both public and private, hence these objections were the result of actual enforcement rather than academic speculation.

About this same time an acute shortage of shielded arc electrodes developed. In an effort to provide a basis on which these scarce electrodes could be supplied to schools, conformance to the code was used as the "yardstick" to determine if a school should receive filler metals.

All of these unfortunate incidents combined to create the impression that this Code was extremely unfair an impossible of compliance. Such a summary judgment, passed upon the Code without benefit of all the facts, is manifestly unfair and should be refuted by presentation of the evidence.

A part of the difficulties leading up to these unfortunate conditions may be traced to the changing tempo of our times. In 1939, 1940 and even early in 1941 there did not exist the tremendous pressure for "all-out production." Factories worked at capacity but were not pushing production. In that period it was considered fundamental that a trainee in welding should receive a thorough grounding in the art. This basic principle was never questioned.

With the advent of actual warfare, conditions changed and production schedules soared. Shipyards, munitions factories, subcontractors and others demanded welding operators. Welding work was broken down so that each operator performed one task repetitively. In short, our war production was going on the "production line." This logically led employers to question the necessity for completely trained welding operators with the result that they asked the schools to turn out trainees who had been schooled in specific operations such as tack welding, flat position welding, etc. Such programs released these partially trained operators to industry sooner than under the long-time plan and thus were of great value in expediting production. The individual shops undertook to continue the training of these operators while they worked, giving them further specialized training suitable for the particular industry. The providing of separate lectures on related welding topics was also one of the first phases of the curriculum to suffer when it became necessary to speed up the courses. In some instances the subjects were briefed and given at the welding stations at the time the problems arose. In other cases, the subject was dropped completely. It is believed that almost everyone will agree that this related information should be provided—the method of doing so being of secondary importance. In normal times the classroom lecture is probably best. In wartime speed-up, discussions at the work space may prove more expedient. In any event to condemn the Code because of this point is to lose sight of the purpose of the Code.

It was this policy of creating short specialized courses that led to the criticism of Part A of the Code for the reasons that the several states had adopted the Code and further that conformance to the Code was necessary to secure electrodes. Thus the schools were confronted with the alternatives of conforming to the Code (even if only in a token manner) in order to survive and secure electrodes, or to violate the Code and face action by some regulatory body and loss of the electrodes.

Thus it will be seen that the questions of hours of instruction and sizes and quantities of machines were actually of minor importance, the big problem being the misapplication of the Code. It is submitted that much of the controversy over this Code could have been avoided had the underlying elements been recognized and dealt with directly. Since the Code has been prepared for the complete training of an arc-welding operator, it follows that for lesser degrees of training only portions of the Code apply. Therefore, for the short-time specialized courses, it would be merely necessary to stipulate the applicable portions of the Code.

An analysis of this problem will reveal that it would not be possible for the Code Committee to prepare individual codes for each special condition since no two conditions are identical. Therefore, it seems logical for the committee to adhere to the original principal of providing a complete code and leaving for the administering bodies the problems of applying it to special cases. It might be observed here, that while these special cases now represent rather elementary training, in the postwar period they will doubtless require instruction of an advanced nature designed for up-grading.

If a need for a given type of specialized course can be demonstrated, the committee stands ready to prepare supplements to the general Code. Such supplements would indicate which phases should be applied to the specific problems. However, the requirements for specialized courses are constantly changing, even now. Present demands seem to tend toward a more complete training rather than the elementary type. With such a changing picture, the wisdom of adhering to the basic Code becomes more apparent.

The question of stipulating minimum hours in a code is one that will always raise discussion. There are those who would eliminate all requirements for hours and base the determination of a candidate's ability on his passing of prescribed tests. The objection to this is that there are schools, and even students, who would devote their entire time to practicing test welding without going through the program of exercises designed to train the student for the various welding problems which will be encountered in industry.

Another question is raised in this connection: are those particularly talented students who are able to finish in less than the minimum specified time, to be required to stay the required time? In such a case, if the trainee has completed all the work and passed all the tests, it seems only logical that he should be released, particularly if industry needs operators urgently. On the other hand, if time is available, such a student should be given additional opportunity to develop his skill further under the direction of the teacher.

In so far as the number and sizes of arc-welding machines are concerned, it is believed that the Code is liberal enough for a complete course. The number of machines must be adequate to provide one for each trainee who is welding, yet not necessarily one for every enrolled student, since part of the time is spent in testing, preparation, etc. Those who would advocate fewer machines than the specified number are running the risk of students standing around idle with the further possibility that they will lose interest. The sizes of machines must be adequate to cover the welding problems of the course. How can a school hope to teach welding with E 6020 electrodes, if all they have is 150-amp. motor generator sets? Similarly how can complete arc-welding instruction be given if only 100-amp. transformers are available? These are not hypothetical situations, but

actual conditions in some of the early wartime welding schools. Their existence prompted the regulations now in the Code. Obviously the machines for special courses should be suitable for the work and the administrative body should make due allowances for this in administering the general Code.

It is admitted that some phases of the Code require modification; these will be cared for in the revision before issuing the final Code. However, it is submitted that the Code Part A as prepared for metal arc welding has proved in general to be a workable code and one which will not create hardship, if properly applied.

This committee has continued its work and during the past year has undertaken a code to cover training of oxyacetylene welding operators for the aircraft industry. This was selected for the second Code to be issued in view of the fact that there has been a large program of welding operator training for the aircraft industry. In order to cover this subject it has been necessary to deviate from the original program of treating the welding of heavy sections and light sections. Aircraft welding is principally on light sections but certain phases overlap into the class of heavy material. In addition special techniques are necessary to handle the problems peculiar to aircraft construction. Therefore, it was decided to prepare a code specifically for aircraft welding instruction.

This second Code has been published for comments under the title, "Proposed Code of Minimum Requirements for Instruction of Welding Operators—Part B-1—Oxyacetylene Welding of Steel-Aircraft." The problem of preparing this part has been greatly simplified by virtue of the fact that the requirements were limited to one industry and the Army and Navy have established definite requirements for their welding on aircraft. It may, therefore, be stated that the requirements of this Code are written around the current military and naval specifications.

A brief review of Part B-1 will reveal that the format adopted for Part A has been closely followed. Only such modifications as were necessary for the aircraft industry have been made. As a result of experience gained in the administration of Part A, certain changes have been incorporated in Part B-1.

Current requirements for aircraft welding provide for two classes of operators, Class A capable of handling unlimited work on a given metal, and Class B to handle more restricted operations. Since the present Army and Navy certification tests are grouped in this order, Part B-1 has been organized to cover this same order. Thus there are two sections, the first of which prescribes for an elementary course to train a Class B operator. The second part provides the material necessary to continue the training of this Class B operator and enable him to qualify for Class A. The two parts taken together constitute the course for complete training of a Class A operator.

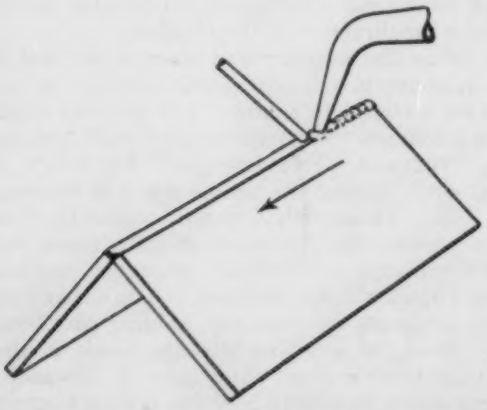


Fig. 1—The Corner Joint Employed to Teach the Principles of Fusion and Penetration

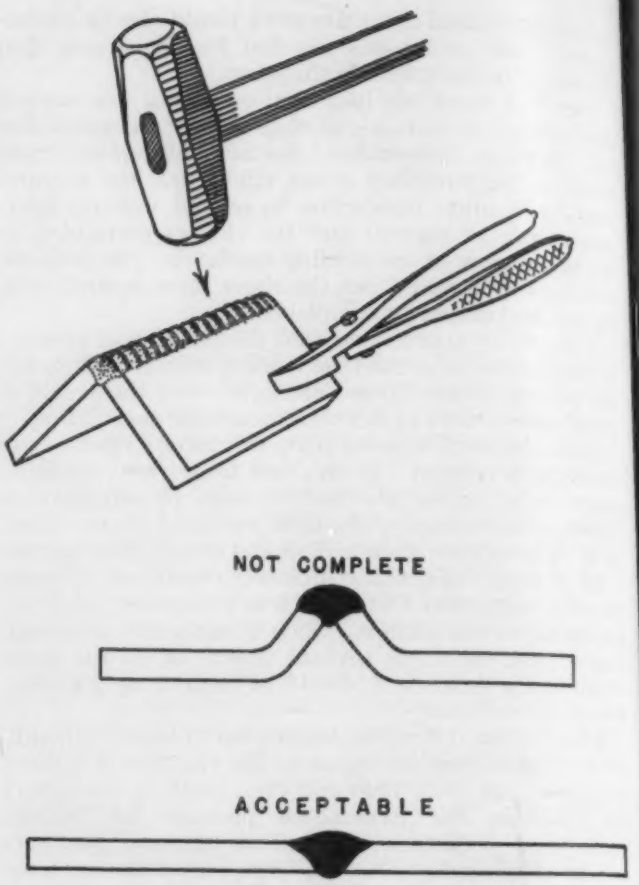


Fig. 2—Testing the Corner Joint

At the completion of each section the appropriate certification tests as required of aircraft welding operators on naval and military contracts are specified. Thus the trainee has a course designed for the work he will perform, and finishing with the actual tests he must be able to pass in industry.

Training Aircraft Oxyacetylene Welding Operators

In the preparation of Part B-1 extensive use has been made of the experience gained in operating schools for training aircraft welding operators. Results from various parts of the country have been correlated in arriving at specific values prescribed. In this connection it has been the writer's privilege to be associated with a course conducted at Pratt Institute, Brooklyn, N. Y. This course, which has been operating about three years, is designed for the up-grading of Class B to Class A operators. In this respect it follows closely the second phase of Part B-1. A study of the operations of this course will prove of value since it follows the proposed code, and the results have been very satisfactory.

This course has been operating continuously 12 months a year since January 1941, and well in excess of 200 trainees have completed the work. As far as it has been possible to determine, every graduate of this course who has taken either the Navy or Army certification tests, has passed successfully.

The course is offered at night in 3-hr. sessions; one class operates three nights a week, the other two nights. Requirements for admission are employment in some

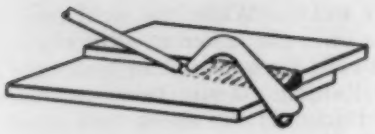


Fig. 3—The Lap Joint, Fillet Welded

form of aircraft production welding and the ability to pass the Class B tests or evidence of having passed these tests. Classes consist of 14 to 18 trainees with two instructors in attendance. One instructor supervises the welding instruction, the other the testing and interpretation of results.

The program of instruction is based upon actual aircraft production in that the joint types employed in aircraft welding are included in the exercises. Where a joint is particularly difficult, preliminary exercises are provided so that the trainee may be gradually introduced to the complexities of the problem.

A fundamental principle is established at the beginning of the course; viz., *every weld must be tested* regardless of how good or poor it may appear. Thus the student is taught to recognize the different types of weld defects and their effect on weld strength. Subsequent instruction at the welding station teaches methods of eliminating or correcting defects.

Each exercise must be satisfactorily completed in sequence before progressing to the next one. Welds are examined for appearance as well as quality and the standard set for perfect work is equivalent to that required in industry. In no case is work acceptable which is not at least 95% of the commercial standard. Obviously such requirements impose upon the instructors the necessity of close contact with industry to keep up to date.

The first exercise to which a trainee is introduced is a corner weld on $^1/_8$-in. thick mild steel sheets (Fig. 1). This is in the nature of a test to determine the skill of the student. While this may seem ridiculously simple, it has been our experience that every candidate fails at least on the first attempt and many require extended instruction to master this problem. No trainee has passed on the first attempt. This exercise is important in the value of the basic principles it demonstrates. In the opinion of the instructors, this is the best method of teaching the importance of fusion and penetration. The test for the welded corner joint is to flatten by hammering (Fig. 2), and then examine for cracks and other defects. A perfect specimen can have no cracks; one with two or three cracks about $^1/_{16}$ or $^3/_{32}$ in. would be valued at about 95%.

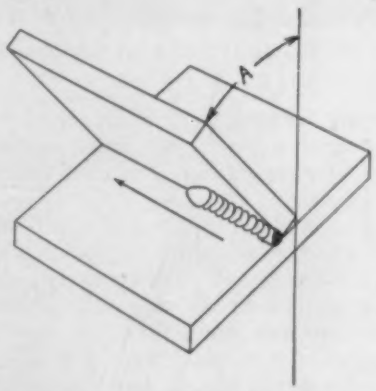


Fig. 6—A Restricted Tee Weld; Angle *A* May Be Varied from 45 to 60°

While this corner weld proves difficult for many trainees, the lessons learned in mastering it are of great value in all subsequent work. Following it, simple butt welds in $^1/_{16}$ and $^1/_8$-in. sheet are made. While this may seem too elementary for students possessing Class B certification, experience has shown that most of them have not fully mastered the making of butt welds without beveled edges. For those who have this skill these are very simple exercises which they complete quickly. A variety of spacings is employed to train the operator in maintaining fusion and penetration under varying

Fig. 4—Welding a Tee Joint Made Up of Unequal Metal Thicknesses

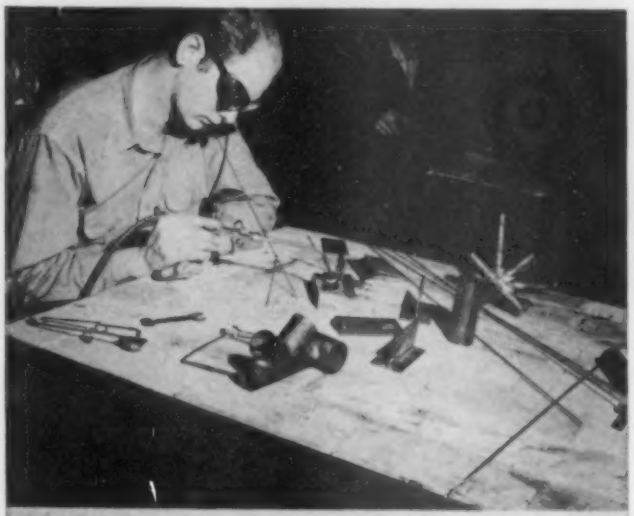


Fig. 5—Examining the Root of a Tee Weld in Relatively Heavy Sheets

conditions. Further, these welds are performed in the flat, vertical and overhead positions.

Following butt welds, the trainee is introduced to lap joints, fillet welded. These lap joints employ sheets of equal thickness, and sheets and plates of unequal thickness. Again welds are made in all positions. These are the first problems the student encounters involving metals of different thicknesses and through them he learns the necessity of proper heat distribution. Typical lap joints are shown in Fig. 3.

The next logical step is the welding of tee joints, em-

Fig. 7—A Typical Example of a Restricted Weld in a Tubing Assembly

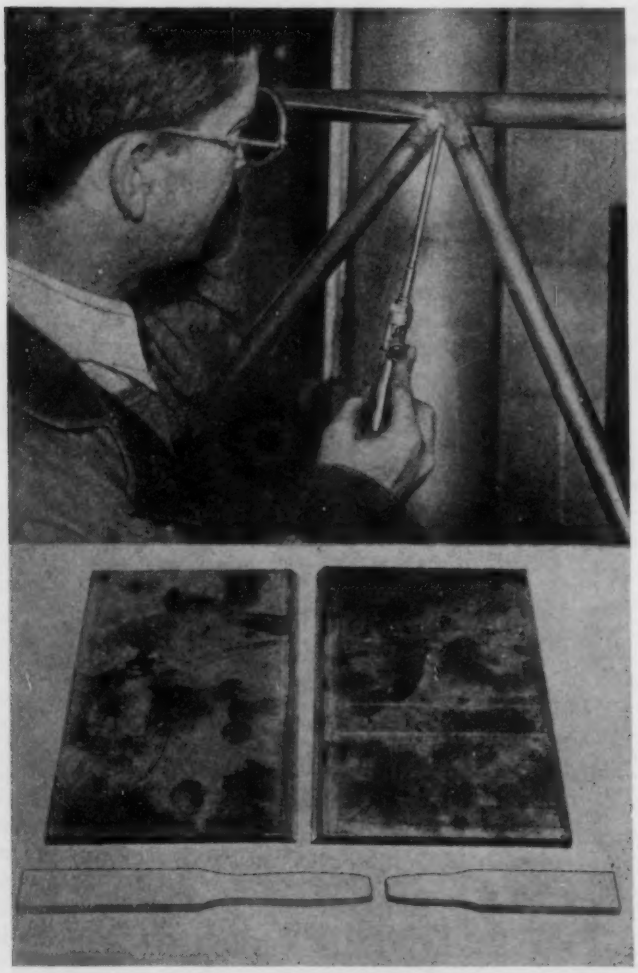


Fig. 8—U. S. Army Test Joint No. 1

To the rear are shown the two plates 6 x 10 x 1/4 in., beveled 45°; to the front is a tested specimen.

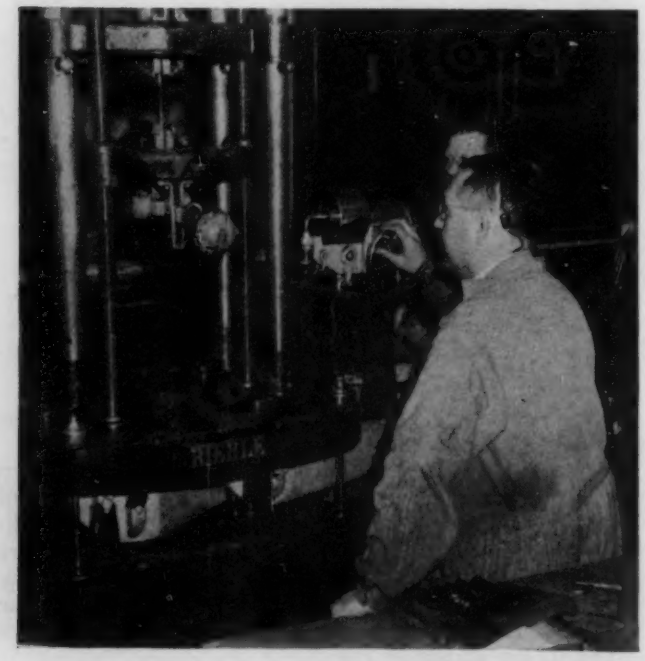
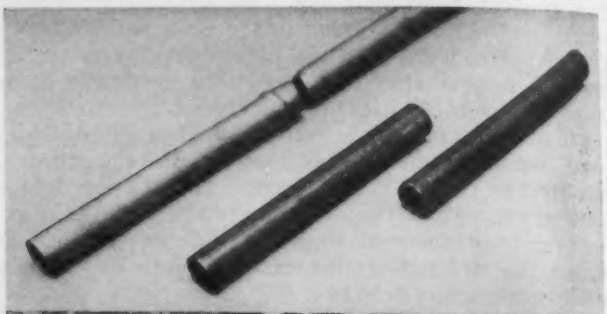


Fig. 9—Testing a Specimen from a U. S. Army Test Joint No. 1

ploying fillet welds. While the weld type is similar to the previous one, the different disposition of the base metal pieces calls for a change in technique and method of heat distribution. Again these are made on sheets of the same thickness and sheets and plates of different thicknesses. Various positions of welding are also employed. A trainee making a tee joint consisting of 1/16-in. sheet on 1/8-in. sheet is shown in Fig. 4. One fault may be observed in this picture. The student is welding on a sheet that is backed up with firebrick. Better results will be obtained if the area under the weld is free of any backing. Note also samples of

Fig. 10—U. S. Army Test Joint No. 2

To the front, two pieces of 1-in. O.D. x 0.065 seamless steel tubing used in the joint; a tested joint is shown to the rear.



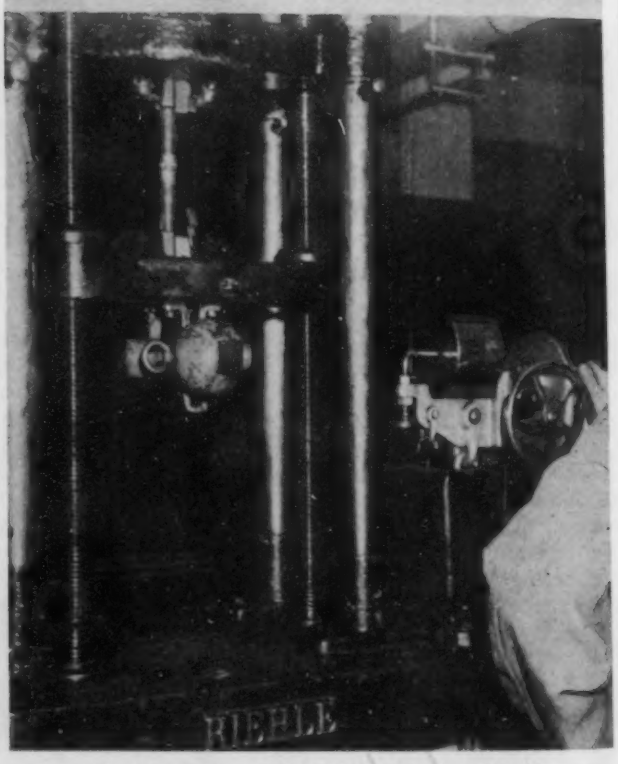


Fig. 11—Testing a U. S. Army Test Joint No. 2

typical aircraft welding which are used to show the trainees the type of work they must perform. Figure 5 shows a student examining the root penetration on a heavier tee joint.

Another, modified tee joint is also provided to teach the technique of depositing welds in close quarter. This restricted tee joint is shown in Fig. 6. This is a very difficult exercise but it represents a fairly common condition encountered when tubes and gussets intersect at acute angles. A typical example of this type of connection is shown in Fig. 7, which represents an intersection of tubes on a fuselage.

Following this butt welding on plates 3/16 and 1/4 in

thick, beveled 45°, is undertaken. The $^3/_{16}$-in. plate welds are mastered with relative ease. The $^1/_4$-in. plate welds, however, seem to be the most difficult work the trainee encounters, particularly in the vertical position.

Up to this point the work has been principally of a general basic nature, teaching the student to master the different weld types in the various positions. Those students who have not previously taken and passed the Class B certification tests are required to do so. These consist of butt welds on $^1/_4$-in. plate and aircraft tubing

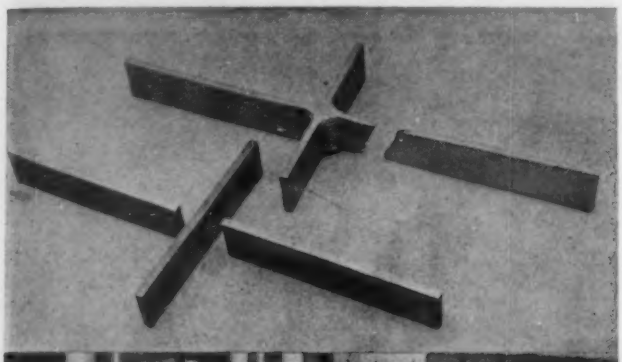
Test Joint No. 1, Fig. 8, is made on two $^1/_4$-in. thick steel plates 5 x 10-in.; the weld is made in the flat position. From this plate at least three specimens such as shown at the bottom of Fig. 8 are machined. These are then subjected to the tension test as illustrated in Fig. 9.

Test Joint No. 2 requires the welding of four specimens as shown in Fig. 10. Specimens are usually made of 1-in. O.D. x 0.065-in. wall thickness tubing. One specimen is welded with the tubes horizontal on the bench, during which they may be rotated; a similar specimen is welded on the bench in the vertical position. A third specimen is welded in the fixed horizontal position (tube position), not lower than the level of the operator's eyes; the fourth and final piece is welded in the fixed vertical position at eye level. The testing of these welds is illustrated in Fig. 11.

At this point it is customary to give the trainee Test Joint No. 3 since the required training and practice for this have been accomplished. This test consists of three pieces of steel plate $1^3/_8$ x 6 x $^1/_4$ in. placed to form a cross

Fig. 12—U. S. Army Test Joint No. 3

To the front are the three pieces of steel $1^3/_8$ x 6 x $^1/_4$ in. which make up the assembly; a tested specimen is toward the rear.



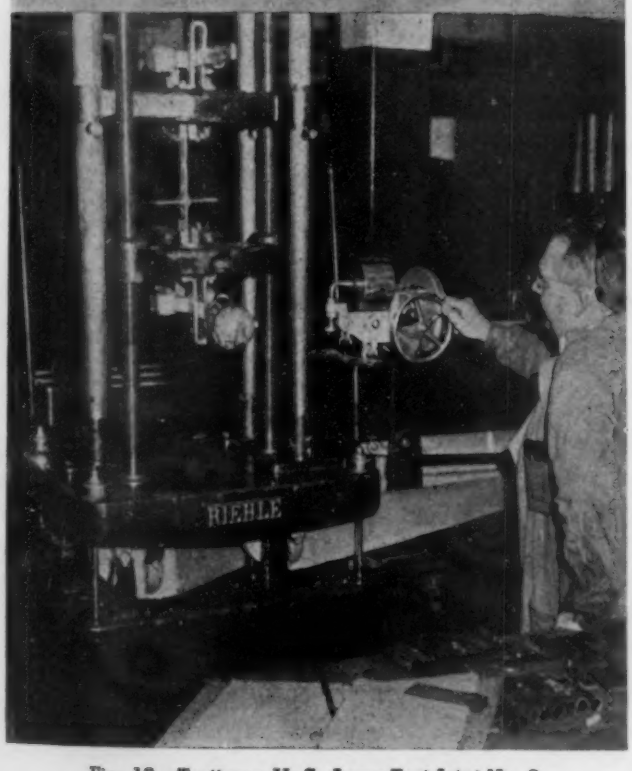


Fig. 13—Testing a U. S. Army Test Joint No. 3

Fig. 14—On the Left Is Shown the Application of the Welding Principles to the Fabrication of Simple Jigs for Use in the Class. To the right the Repair of an Aluminum Casting by Welding

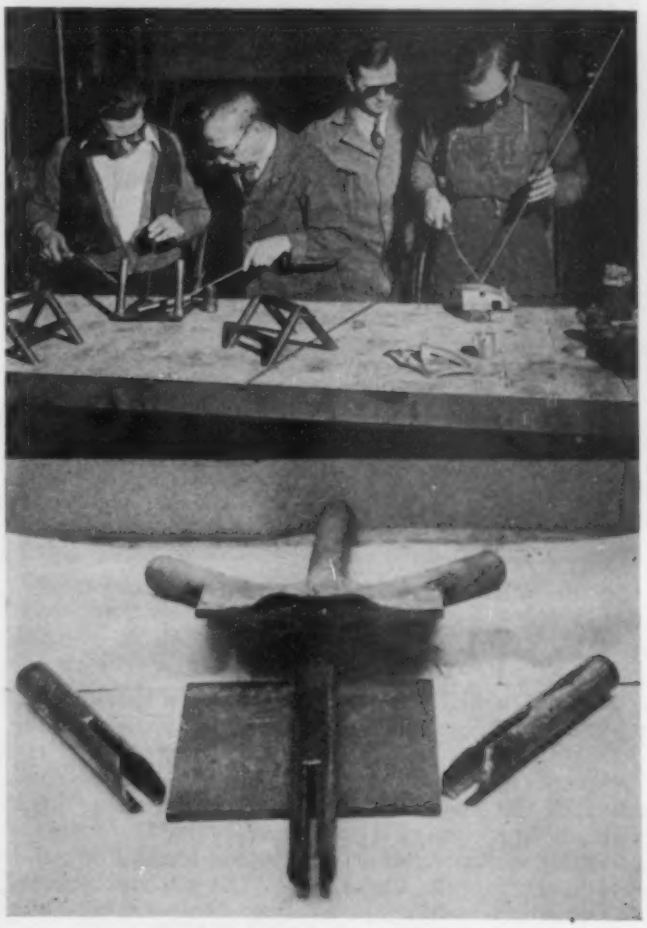


Fig. 15—U. S. Army Test Joint No. 4

The 6 x 6 x $^1/_4$-in. steel plate and three slotted tubes are shown in the lower portion. A welded specimen which has been cut, polished and etched may be seen above.

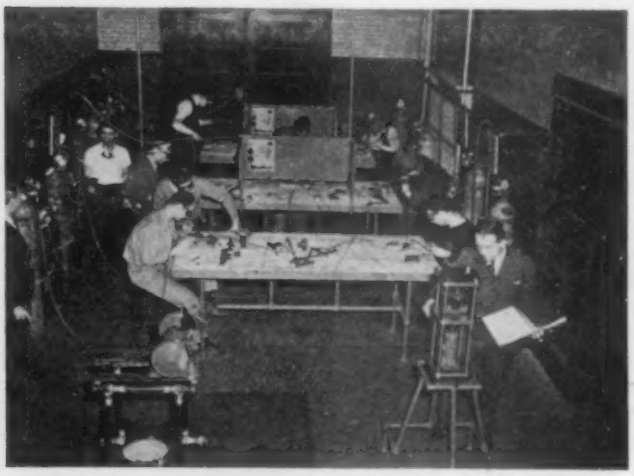


Fig. 16—The Original Facilities at Pratt Institute for Up-grading Class B Aircraft Welding Operators

Fig. 17—A General View of the Welding Department in an Aircraft Parts Subcontracting Plant

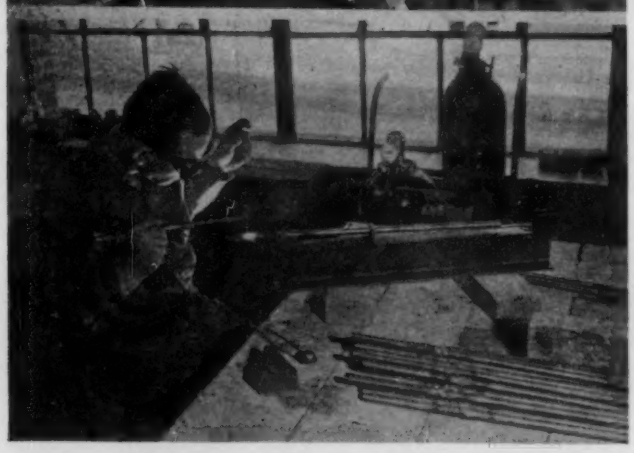


Fig. 18—Welding Thin-Walled Tubing to Heavy Stud. Operator Is a Graduate of Training Program Described

as pictured in Fig. 12. A tested specimen is also shown in Fig. 12, while the actual testing may be seen in Fig. 13.

All that remains in the program of training is the application of these fundamentals to typical aircraft joints and the completion of Test Joint No. 4. The former is accomplished by welding tubing assemblies and intersections at various angles, with and without gussets. Included in this will be the welding of thin-walled tubing to heavy plates, simulating the fabrication of engine mounts. At times it is possible to utilize these exercises in the production of small jigs and equipment as may be seen in Fig. 14. Testing of such welded intersections, commonly called clusters, is difficult except by sectioning, polishing and etching.

Practice on clusters progresses quite rapidly since the trainee has already had complete grounding in the fundamentals. The final step is Test Joint No. 4, illustrated in Fig. 15. As may be seen, this is a complicated cluster of three 1-in. O.D. x 0.065-in. wall tubes welded to $^1/_4$-in. thick plate. A tested cluster which has been etched is shown above the parts comprising the cluster.

The facilities employed at Pratt Institute for this course, while not large in extent, are nevertheless complete and adequate to perform a thorough job. Figure 16 shows the welding workroom as originally established for twelve trainees. Note particularly the guided bend test machine. This test is employed in modified form on all butt welds. The modification is simply that the welded pieces are bent without removing reinforcement. To compensate for the severe stresses induced by this condition a plunger of larger radius is employed; i.e., a plunger suitable for $^1/_4$-in. thick specimens is used on all thicknesses up to and including $^3/_{16}$ in. while a plunger for $^3/_8$-in. specimens is used for $^1/_4$-in. plate welds. The corner welds as well as the lap and tee welds are tested by hammering in such a manner as to stress the root of the weld.

Perhaps the most important testing equipment for aircraft welding operator training is the tensile testing machine. We are indeed fortunate in having this equipment available since it permits the trainee to observe his specimens under test and understand what takes place.

The proof of the success of any training program is the quality of work performed by the graduates when actually employed in industry. Glidden Buick Corp., Airplane Parts Division is engaged in subcontracting the welded fabrication of airplane parts, subassemblies, jigs and fixtures. All of the oxyacetylene welding operators employed at this plant have successfully completed the course at Pratt Institute. In Fig. 17 is shown Glidden's welding department, equipped to operate from mani-

Fig. 19—Welding a "Fish-Mouth" Connection—an Example of Lap-Joint Connections

Fig. 20—Welding a Tee Joint for a Bracket

Fig. 21—Production Welding of Special Clamps Illustrating Tee-Joint Assemblies

Fig. 22—A Difficult Welding Assembly Requiring Carefully Planned Welding Sequence to Preserve Accuracy

folds. Figure 18 is an example of the welding of thin to heavy members; the light-walled tubing is being welded to a heavy threaded stud, using the lap joint and fillet weld. Observe the collar joined to the tube at midpoint using the fillet weld. Still another application of this weld type may be seen in Fig. 19. Note particularly the neat, clean welds.

The tee joint, fillet welded, is shown in Fig. 20 which is a view of production welding of special brackets. Another view of production welding employing this same joint type of double ended clamps is pictured in Fig. 21. The large clamp bands visible at the right of the table also involve to a limited extent the use of the restricted tee joint.

Complicated assemblies generally require the use of several types of welds together with a carefully planned sequence of welding to avoid distortion and cracking. The unit which is shown during welding in Fig. 22 is very complicated and exceedingly important. Accuracies measured in thousandths of an inch had to be maintained. This operator, who was an auto mechanic a year ago, now welds these parts with a minimum of rejections.

Accurate jigs are used extensively in aircraft production to assure interchangeability of parts. An assembly ready for tack welding in such a jig is pictured in Fig. 23. Observe the variety of joint types in this member. Other jigs are used for welding subassemblies (Fig. 24). This is a unit which will be later welded into a large structure on which a high degree of accuracy must be maintained.

All of the work shown in Figs. 17–24 is being regularly performed by operators, many of whom had never done any mechanical work previously. In addition, all of these assemblies are made of chrome-molybdenum alloy steel. The success of their work is evidence that the program of training at Pratt Institute is workable and yields results.

The aircraft welding course as offered at Pratt Institute is really an up-grading course as has been noted previously. The program calls for 108 hours of instruction. As originally planned, separate lectures on related welding topics were included. However, after the first term of three months, it became increasingly difficult to adhere to the lecture program as some trainees completed the work faster than others, creating the condition of having both beginners and advanced students in the one class. This has been overcome by providing explanations of each phase of the work as the individual undertakes it. The current candidates for

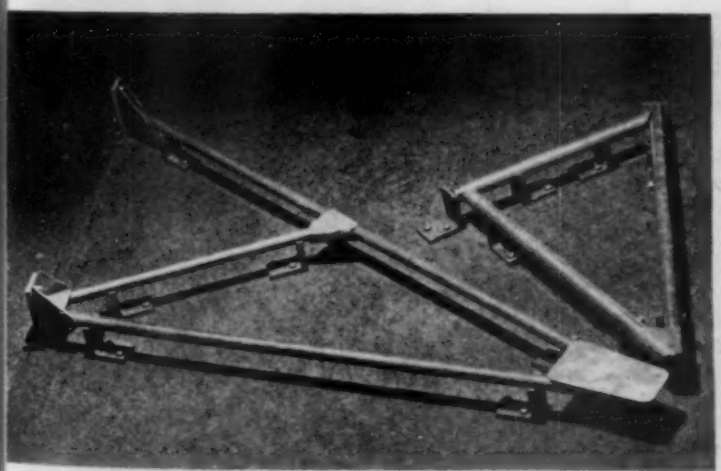


Fig. 23—Typical Aircraft Units Handled by Graduates of Course Described. Note Ingenious Jig

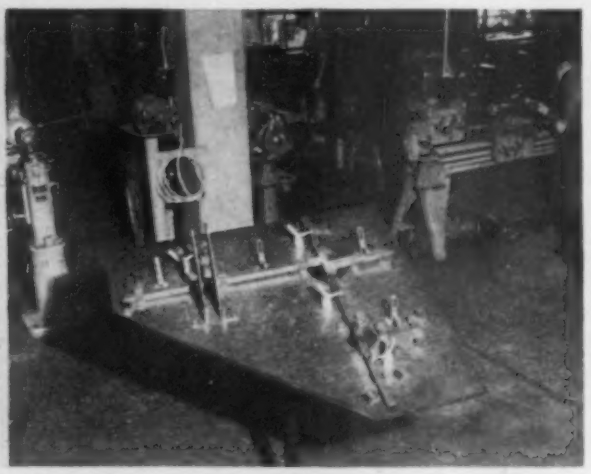


Fig. 24—An Intricate Subassembly Held in Jig for Welding

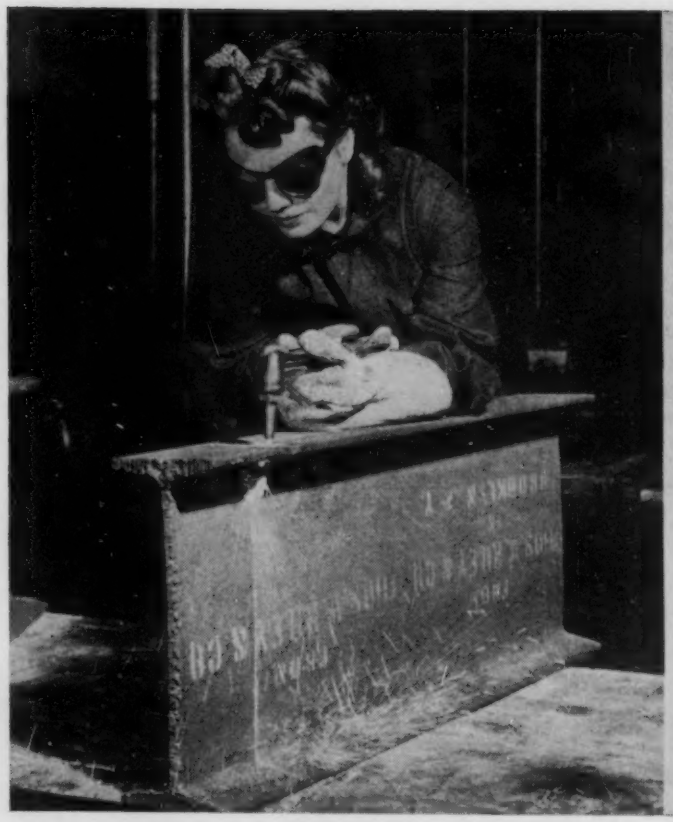


Fig. 25—Instruction Is Provided in Hand Cutting in Specialized Courses

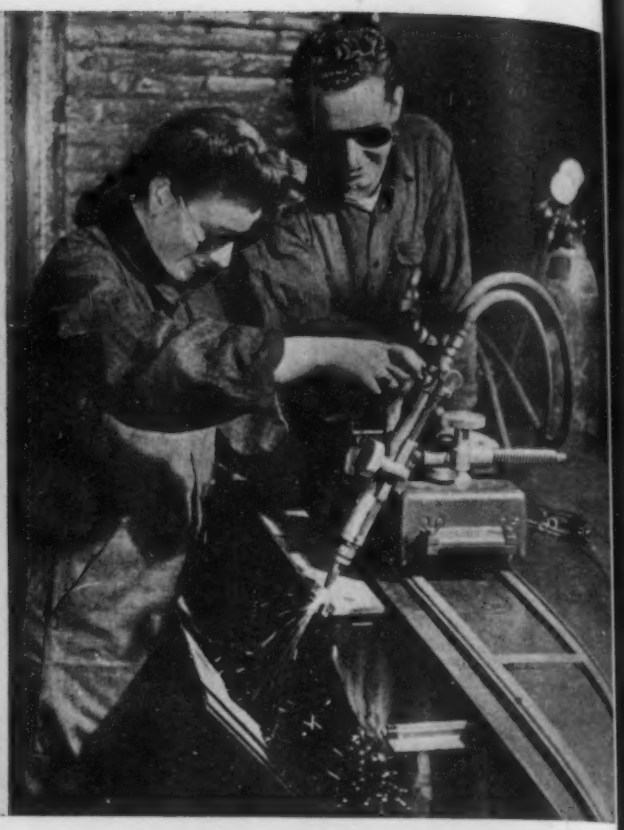


Fig. 26—Machine Gas Cutting Is Taught Using a Straight-Line Cutting Machine

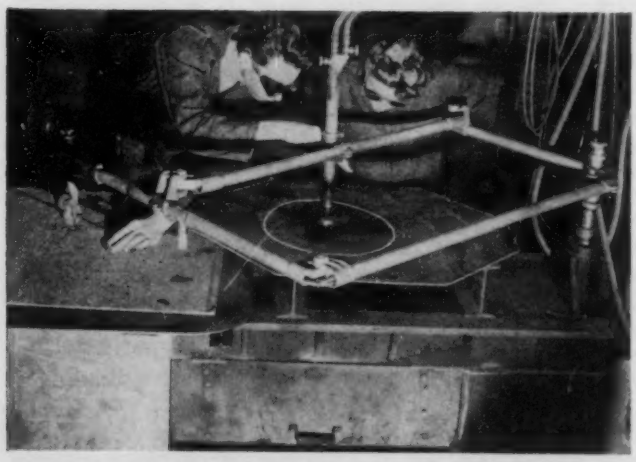


Fig. 27—Principles of Intricate Shape Cutting Are Taught Using A Cutting Machine Made Before World War I

this course, coming from other than the mechanical trades, are somewhat slower to grasp the work. Hence it is now taking 25–50% longer to bring these trainees to the point where they are able to meet the requirements.

Other courses in general oxyacetylene and metal arc welding, oxyacetylene cutting as well as specialized courses in aluminum welding and pipe welding by metal arc and the oxyacetylene processes have been offered for war workers at Pratt Institute. These have usually been designed to fit some special need of a specific industry and have lasted only as long as need existed.

Some of this training is illustrated in Figs. 25, 26 and 27 In this work girls are receiving elementary training in the oxyacetylene cutting processes. Considering it to be the work of a novice, the cutting of the I-beam shown in Fig. 25 is quite good. The use of straight line cutting machines, important tools of war production, is included in this course, Fig. 26. Even an old-time shape-cutting machine of World War I vintage is pressed into service (Fig. 27) to teach the principles of machine gas cutting.

Conclusion

This review of some phases of the welding operator training program—admittedly incomplete since it does not cover shipbuilding and welding for ordnance—does demonstrate that the codes as prepared can be applied practically as evidenced by the course for aircraft welding operators. It also illustrates that where minor problems arise necessitating modification of the set program, these can be dealt with expeditiously and effectively if we will but apply common sense.

With the passing of the peak in the demand for welding operator training, we may expect to see the trend shift to longer, more complete courses which produce better-trained operators. Even now the demand is for better-trained operators, particularly in view of the few failures in welded structures which have been publicized.

Acknowledgments

The author wishes to acknowledge the fine assistance rendered by Professor Burley and Professor Jones of Pratt Institute in making available the data on operations at that school and providing photographs of the work.

For the excellent illustrations of actual shop production, we are indebted to Glidden Buick Corp., Airplane Parts Division, to whom we offer our sincere appreciation.

To my fellow instructors at Pratt, Messrs. V. Forgett, J. Van Laethem and E. H. Roper I offer my personal appreciation for their cooperation.

Why the Weld Recorder*

By J. R. Fetcher and J. Van Den Beemt†

RESISTANCE welding has been defined as the welding together of two or more sheets of metal by a combination of pressure and heat generated by an electric current. The heat generated in the weld zone is equal to the product of I^2RT, which is: the weld current squared, multiplied by the resistance of the weld zone, multiplied by the time of current flow.

The principal variables of a resistance welding setup are:

1. Weldability (surface finish, cleanliness and fit).
2. Electrode size and shape.
3. Electrode force.
4. Current.
5. Time.

Weldability, electrode size and shape and electrode force are the variables which control the resistance of the weld zone. These can be controlled by visual supervision in the shop. The other two variables, current and time, cannot be controlled visually because variations in them sufficient to affect seriously the weld strength do not affect the appearance or sound of the weld. The most accurate means of indicating variations in the I^2T value is by the use of the Ampere-Squared-Second Recorder—commonly called the weld recorder. A photograph of a weld recorder installed in a welding timer is shown in Fig. 1.

* To be presented at the Annual Meeting, A.W.S., Chicago, Ill., Oct. 18 to 21, 1943.

† Edward G. Budd Manufacturing Co., Philadelphia, Pa.

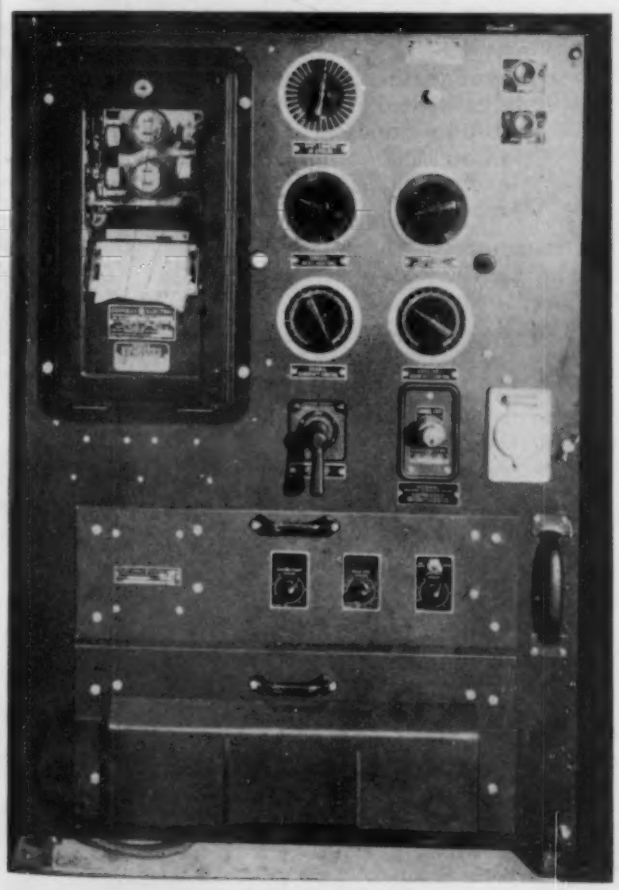


Fig. 1—The Weld Recorder Installed in a Welding Timer. Sequence Panel and Voltage Compensator Are the Two Pull-Out Panels at the Bottom

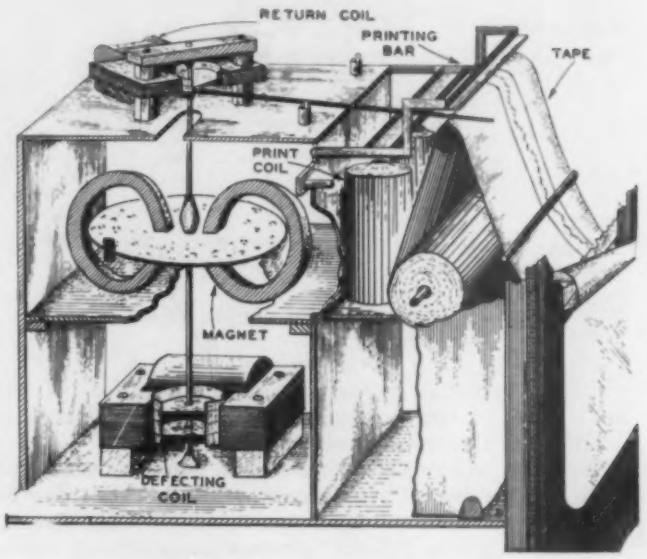


Fig. 2—The Operating Mechanism of the Recorder

The Operation of the Weld Recorder‡

The mechanism of the recorder is illustrated in Fig. 2. It has two electrical circuits. One, connecting the deflecting coil to the weld circuit, controls the recorder needle deflection. The other, connected to the timer circuit, controls the sequence of operations of the recorder following the weld, that is, the print, the needle return, the paper travel and the timer lockout in the event of an unsatisfactory weld recording.

Figure 3 shows a typical weld circuit for light gage stainless steel. The weld is made with a current of 3300 amp. for 3 cycles duration. The primary current is 330 amp., and recorder current transformer and potentiometer are adjusted to deliver 3.3 amp. to the recorder deflecting coil. The torque applied to the recorder shaft is proportional to the square of the current through the coil. The time of rotation is equal to the time of current flow. Three and three-tenths amperes for 3 cycles produces (approximately) 30 ampere-squared-cycles or 30 "ascs",§ the value required to deflect the recorder needle to the center of the "safe zone" on the recorder tape. Regardless of the "asc" value used in making the weld, the recorder deflecting coil must receive 30 "ascs" to

‡ Details of the electrical operation of the Ampere-Squared-Second Recorder have been covered in a paper by T. A. Rich, A.I.E.E., 41-88, April 1941.

§ There is no satisfactory unit for the value of I^2T measured by the weld recorder. In this text the word "asc" is an abbreviation of the quantity "ampere-squared-cycles."

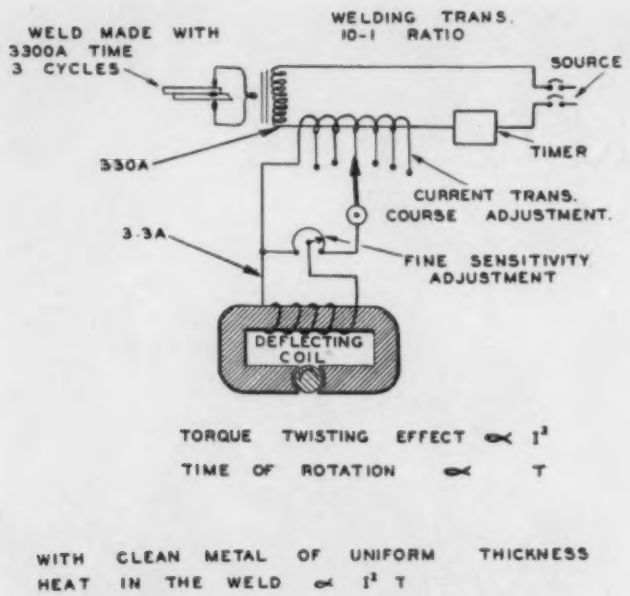


Fig. 3—Circuit Showing Connections for Recorder

produce a normal deflection. Any variation in the "asc" value of the welding current will be reflected in variations of the recorder needle deflection.

The heat generated in the weld is equal to the I^2RT of the weld zone. The value of weld resistance can be held constant with proper supervision and equipment. Then variations in I^2T will produce proportional variations in the heat generated in the weld. Inasmuch as the strength is a function of the heat delivered to the weld, the recorder will indicate when the weld strength has varied beyond allowable limits.

The Function of the Weld Recorder

The recorder can be used only with welding timers provided with perfect synchronous control. When the recorder was installed recently in a conventional welding circuit of one large manufacturer, the recorder would not operate consistently. It was discovered that irregular current loops caused variations in I^2T. The circuit which had been used in industry for some time had to be altered to eliminate the trouble.

It is important to understand that the recorder is an auxiliary piece of apparatus whose function it is to check the current and time. It does not relieve the user from the necessity of providing adequate feeders and/or voltage compensators to reduce the voltage variations and hence hold current fluctuations to a minimum. Poor regulation will result in poor welds and in an excessive number of recorder lockouts with a consequent loss in production. In addition to good regulation and voltage compensation it has been found desirable to add, in certain applications, another device called a half-cycling-protective-relay. Should one ignitron fail to fire, thereby causing poor welds or possible damage to the equipment, this relay will automatically shut down the timer. Good line regulation, voltage compensation, sequence timing, and half-cycling protection all help to assure the necessary control of current and time. The recorder provides an important check on regulation and the operation of the timer; it also indicates I^2T variations from other sources.

SHOP STAINLESS STEEL WELDING CHART

THICKNESS IN.	ELECTRODE DIAM. IN.	NET ELECTRODE PRESSURE LBS.	TIME CYCLES	MINIMUM WELD STRENGTH D.S. 1/4 H.	MINIMUM WELD STRENGTH 1/2 H. F. H.	APPROX. WELD DIAM. IN.	MIN. WELD SPACING IN.	MIN. LAP IN.	MIN. FLANGE WIDTH
.006									
.008									
.010	3/16	230	3	230	275	.070	3/16	3/16	1/4
.014									
.020									
.030									
.050									
.060									
.080									
.100									
.125									

APPROVED WELD MUST HAVE PENETRATION IN OUTSIDE SHEETS BETWEEN 50 & 80%.

Fig. 4—Typical Welding Chart with Data Filled in for 0.010-In. Stainless Steel

The Weld Setup and Test Weld

The recorder is valuable only in conjunction with proper test welds and proper usage. Its purpose is to compare the electrical conditions under which a test weld is made to the electrical conditions of welds made in the job. To obtain full benefit from the recorder it is necessary that a standard weld setup and test procedure be followed. Standard welding charts, such as the one shown in Fig. 4, give complete weld setup information for various metals provided the pile-up conditions do not exceed certain limits.

The setup procedure is as follows:

1. Determine the thickness and hardness of the metal to be welded and consult the welding charts for setup information for these conditions.
2. Select welding equipment which will fit the job, develop sufficient electrode force and have proper tip diameter.

The resistance of the weld zone has now been established. The next step is to set the timer whose control panel is shown in Fig. 1.

3. Set the "Time" dial to the weld time in cycles specified by the chart.
4. Adjust the "Heat" dial (weld current) while making welds on test metals identical to the

Table 1—Weld Setup Variables to Be Observed When Reproducing a Welding Condition

1. The Metals:
   - (*a*) Type of metal
   - (*b*) Thickness and number of sheets to be welded
   - (*c*) Surface, finish and cleanliness
   - (*d*) Metal fit
2. The Weld Conditions:
   - (*a*) Shunted current effect of adjacent welds
   - (*b*) Parallel or series resistance changes due to unusual pile-up conditions
   - (*c*) Electrode tip condition
3. Setup Conditions:
   - (*a*) Increased secondary reactance from steel jig parts between or near the secondary cables or the arms of the welding tool
   - (*b*) Series of parallel circuits through jig parts
   - (*c*) Work not held squarely between electrodes as a result of limited space for the tool or improper tool fit

metals to be welded, until welds are obtained which appear satisfactory for testing.

Now the "asc" value for the test weld has been established. However, while the "Heat" setting was being established, the recorder controls were set so that the test weld was recorded as "safe" on the recorder chart. If the test welds are of satisfactory strength and penetration, the recorder will compare the "asc" value of these tests welds to those made in the job.

If a satisfactory test weld has been made with the recorder deflecting to the "safe zone" and the welds made in the job do not produce a similar recorder deflection, the test weld conditions may not have duplicated the welding job. Table 1 provides an analysis of the three prime considerations which must be taken into account when duplicating a welding condition to make test welds.

Variables Affecting Weld Strength and Recorder Deflection

Weld time variations which may be caused by faulty timer operation or by the operator opening the initiating circuit before the weld time is completed. The use of sequence control will relieve the problem of the interrupted weld.

Weld current variations which may be due to any of the following:

Line voltage variation which will not only affect the weld current directly but will also affect the current indirectly because of its influence on timer operation. The voltage compensator will materially reduce this effect.

Weld circuit resistance and reactance variations. These may be caused by changes in spacing between secondary cables, welding with varying amounts of steel between the welding cables or the arms of the welding tool, loose cable connections and heating in the transformer, secondary cables or welding tools. In portable welding applications, water-cooled concentric secondary welding cables will eliminate these variations to a large degree and offer the other advantage of ease of handling.

Weld zone resistance changes, due to poor metal fit, or the presence of dirt, ink or paint, and sometimes irregular tip force.

Variables Affecting Weld Strength But Not Affecting Recorder Deflection

In light gage metal, flattening of the electrode tips may not affect the recorder deflection but will cause poor welds. The "asc" value of the weld remains unchanged, but the heat is generated over a larger area and the temperature does not reach a value sufficient to fuse the metals together.

In welding light gage metal a reduction of tip force results in "pin-point" welds of low strength. However, the recorder deflection may not be affected.

In the above listed causes for poor welds, those which can be observed visually can be controlled by shop supervision and those which cannot are checked by the weld recorder. Trained welding supervisors and the recorder are both essential to the production of consistent welds.

The Value of the Weld Recorder

The value of the recorder can be best demonstrated by showing some typical recorder charts and interpreting their records. In all these charts the "safe" zone repre-

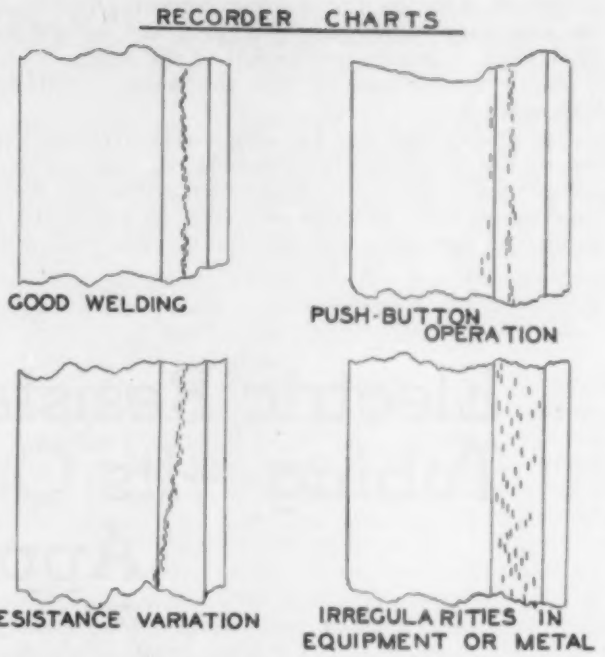


Fig. 5—Typical Recorder Charts. Safe Zone Is Limited by the Two Lines at the Right of the Recording Tape

sents a range of $\pm 15\%$ variation in I^2T. The first chart in Fig. 5 shows a perfect record. This can be obtained if the welding setup, power supply and other variables are properly controlled. Heating of the transformer, cables or welding tools will frequently increase the secondary circuit resistance sufficiently to affect the recorder, as shown in the second chart. The third chart is a record of welds prematurely interrupted by a manually controlled initiating circuit. The very irregular record on the fourth chart was caused by either poor fit of the metal being welded or improper operation of the equipment. Worn or burned relay contacts or faulty tube operation are frequently responsible for irregular records such as this.

Figure 6 shows the effect of changes in spacing of the

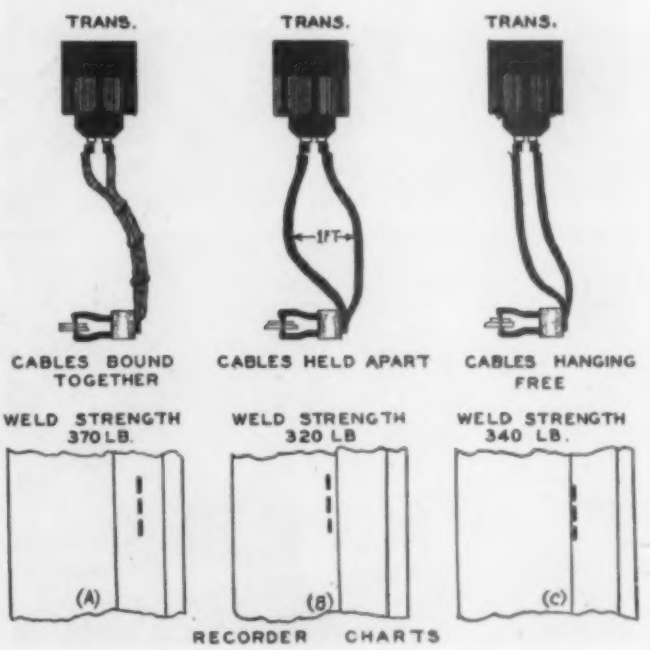


Fig. 6—Weld Set-Up Variables to Be Observed When Reproducing a Welding Condition

secondary cable on the welding current. In this test, the secondary cables were 8 ft. long and carried about 3500 amp. The recorder record of the welds produced is shown in conjunction with the setup conditions of each case.

The weld recorder is valuable to the Welding Supervision, the Welding Maintenance, the Production Department and the Sales Department. For the Welding Supervision it is valuable not only to check the uniformity of the work but also for the psychological influence it extends over the welding operator who knows that a record is made of the work he does. For the Welding Maintenance it is a constant check on the operation of the welding timer and setup. For the Production Department it is assurance that while working at maximum possible speed, the welding is consistent. For the Sales Department there is assurance to the customer that those welding variables which cannot be checked visually are under observation on the chart of the weld recorder.

Electric Resistance-Welded Steel Tubing—Its Quality Control and Application*

By R. D. Malm†

AS AN introduction to any discussion on quality control of electric resistance-welded steel tubing it seems essential that we consider briefly the basic operations involved in its production, which are as follows:

A coil of strip steel is fed into a conventional multiple-stand cold forming mill which bends the strip progressively and continuously into a cylindrical form with an open seam.

This cylinder is forced beneath a pair of roller electrodes which make contact one on each side of the seam, close to the edges of the seam cleft. These electrodes are connected to a suitable power source, of high amperage and low voltage, so that current flows from one electrode to the other as soon as the edges of the open seam tube are pressed into contact. The high resistance of these rough edges to the passage of current develops a highly localized welding heat. Pressure is simultaneously

* To be presented at the Annual Meeting, A.W.S., Chicago, Ill., Oct. 18 to 21, 1943.

† Clayton Mark & Company, Evanston, Ill.

Fig. 1—Quality Control Must Start with the Selection of the Raw Material in the Form of Strip Steel

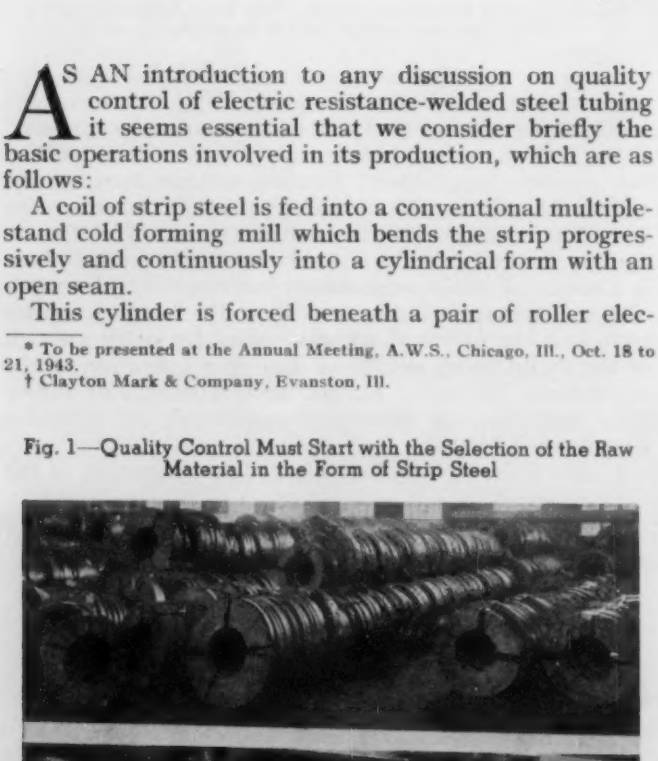


Fig. 2—The Multiple-Stand Cold-Forming Mill Bends the Strip Progressively and Continuously Into a Cylindrical Form

Fig. 3—The Expanding and Flanging Test, and the Flattening Test Are Typical of Routine Check Tests That Are Used to Control Weld Quality During Production

Fig. 4—Typical Crush Test Specimen, Before and After Testing

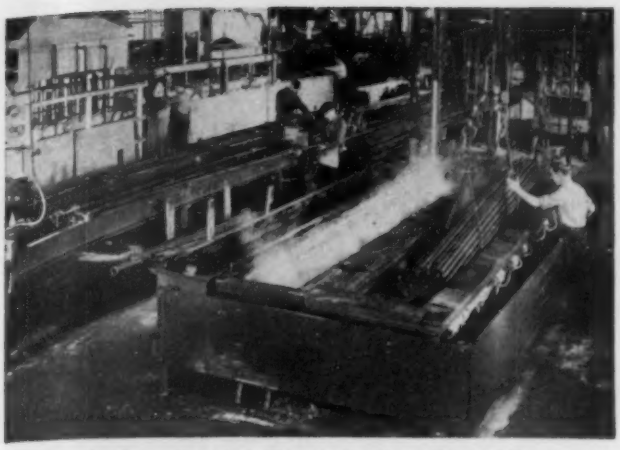


Fig. 5—The Draw Bench Is Used to Produce Special Sizes or to Impart Special Physical Characteristics to the Tubing

applied to force these heated surfaces together, producing extrusion and plastic flow of the heated metal and causing a slight upset or burr to form on both the inside and outside of the welded seam.

The outside burr is shaved off, and the inside burr is either left in or removed by shaving or rolling where the diameter is sufficient to permit the operation. This work is done on the welding mill while the weld metal is still hot.

The weld metal cools rapidly, is subjected to cooling stresses, and reaches a hardness in this highly restricted weld zone of about 10 points (Rockwell B scale) beyond that of the parent metal.

After the welding operation, the tube is about $^1/_{32}$ in. oversize in diameter and is brought to its final finished diameter by passing through several stands of cold sizing rolls. It is then rough cut to lengths by a cut-off machine which moves with the tubing so that there is no interruption of the forming and welding operation.

This tubing as it emerges from the welding mill is commonly referred to as being in the "as-welded" condition. For a majority of applications tubing in this condition will be found most economical as well as highly satisfactory in service.

The wall thickness of welded tubing is as uniform as the steel from which it is made; hence a high degree of concentricity is an inherent characteristic of this tube-making process.

Subsequent operations such as cold drawing for closer tolerance or special sizes, and metallurgical treatment such as stress relieving, annealing or normalizing, have definite effects on the physical characteristics of the processed tubing.

By means of the proper application of the several processing operations, either singly or in combination, it is possible to produce welded tubing which will have any physical properties that may be desired in the service for which it is intended.

The function of the Process Engineer in a tubing mill is to investigate each application or order for tubing and to determine what qualities are most essential to obtain.

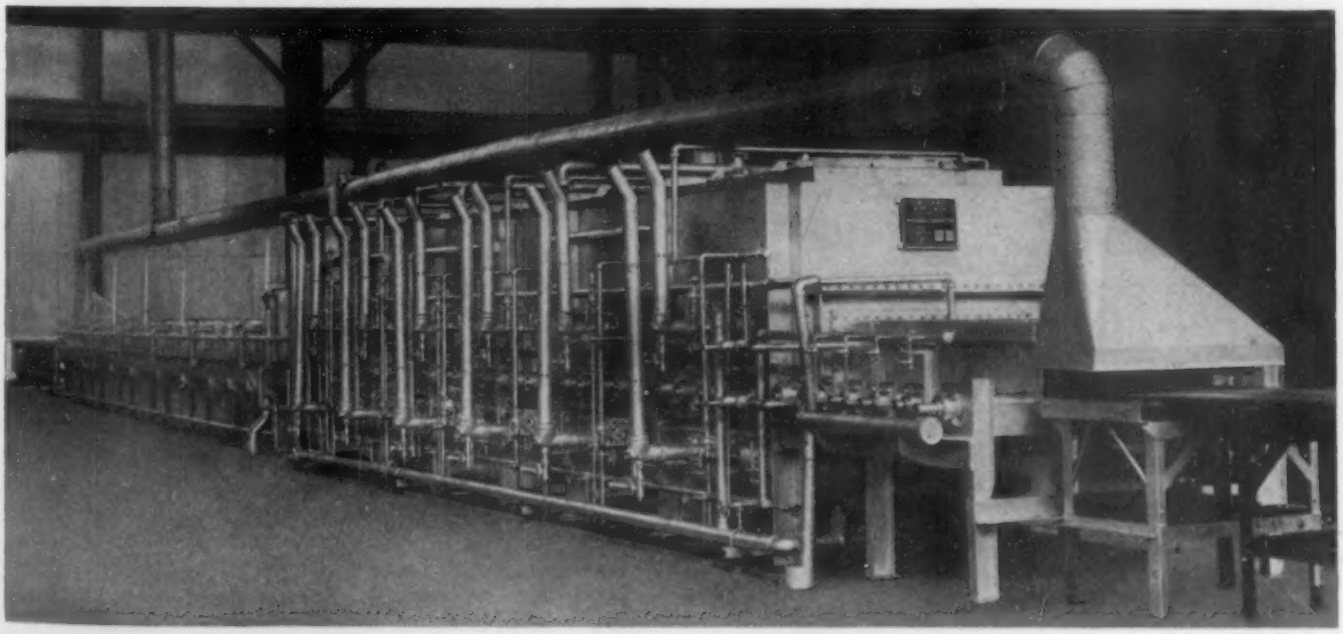
With these data before him, and knowing the effects produced by various methods of processing, he is in position to write up a process specification which will impart to the tubing the desired qualities. Also, he can define a test routine which, if followed, will reject any product failing to reach the standards as set up.

Quality control must start with the selection of the raw material in the form of strip steel, taking into consideration the following factors when specifying the material:

1. Chemical analysis.
2. Surface finish—hot rolled or cold rolled.
3. Thickness tolerance.
4. Hardness.
5. Type—open hearth, electric furnace, rimmed, killed.
6. Grain size.
7. Camber.
8. Single slit or multiple strand

and numerous other factors which may have a bearing on the quality of the finished product.

As an example of conditions affecting the strip steel, it has been the practice of certain strip mills to butt weld short coils of hot bands together prior to cold rolling. The subsequent cold reduction of these unnormalized butt welds creates a hazard in the quality



Courtesy of Surface Combustion

Fig. 6—Modern Controlled Atmosphere Furnaces Are Used for Stress Relieving, Annealing and Normalizing

Fig. 7—The Concave Rolls of the Straightener Impart a Spiral Motion to the Tube, Causing It to Rotate While Moving Forward. The First Set of Rolls Produces a Definite Bend, Which Is Compensated by the Second Set, Resulting in a Straight Tube

control of the finished tubing. From a practical standpoint, the simplest solution is for the strip mill to identify such welds by punching a $^1/_4$-in. hole in the strip close to the weld, so that the tube sections containing the welds can be readily recognized and discarded.

Proper forming of the material prior to welding, in order to have the edges butt properly under the electrodes, with a cross section of correct curvature, is of the utmost importance. If all the contributing factors have been properly coordinated up to this point, the welding operation becomes simple and automatic, as all the operator needs to do is to adjust the heat, speed and pressure to give the desired weld, these being the variable elements of the welding operation.

The welding operation cannot be adjusted to compensate for a variable or poor quality steel, nor for badly formed open-seam tubing with wavy edges and irregular contour.

These remarks are made with no thought of belittling the welding operation but rather to show the necessity of proper coordination of all factors that work together to control the quality of a welded product. The welding is only one operation in a sequence and cannot be expected to compensate for an accumulation of errors from other sources; hence the scope of quality control must be all inclusive.

In order to turn out a high quality product a tubing mill must be highly organized with laboratory control of both raw material and finished product. The engineering staff must be able to work out adequate equipment design, to create specifications covering materials and processes and to conduct research on problems involved in all operations. The mechanical men not only must be skilled in their own special jobs, but they must also be accustomed to precision work in tooling and setup procedure.

The electric resistance-welded tubing industry is unique in its efforts to interchange ideas and work out standards of quality, together with product research,

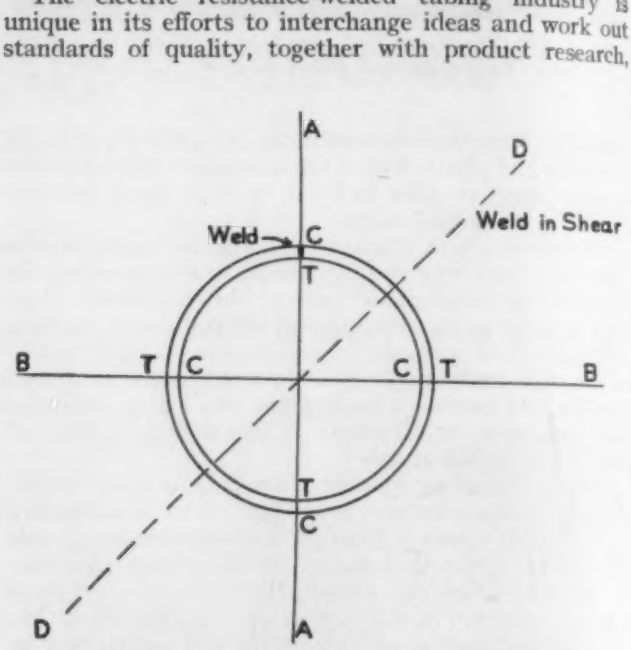


Fig. 8—Nature of Stresses on Weld During Straightening

With rolls contacting in plane *A-A'* areas marked *C* are in compression, areas marked *T* are in tension. One reversal of stress occurs with each half revolution. There are 2 sets of rolls, therefore, there are 4 complete reversals of stress, all of them beyond the yield point of the material.

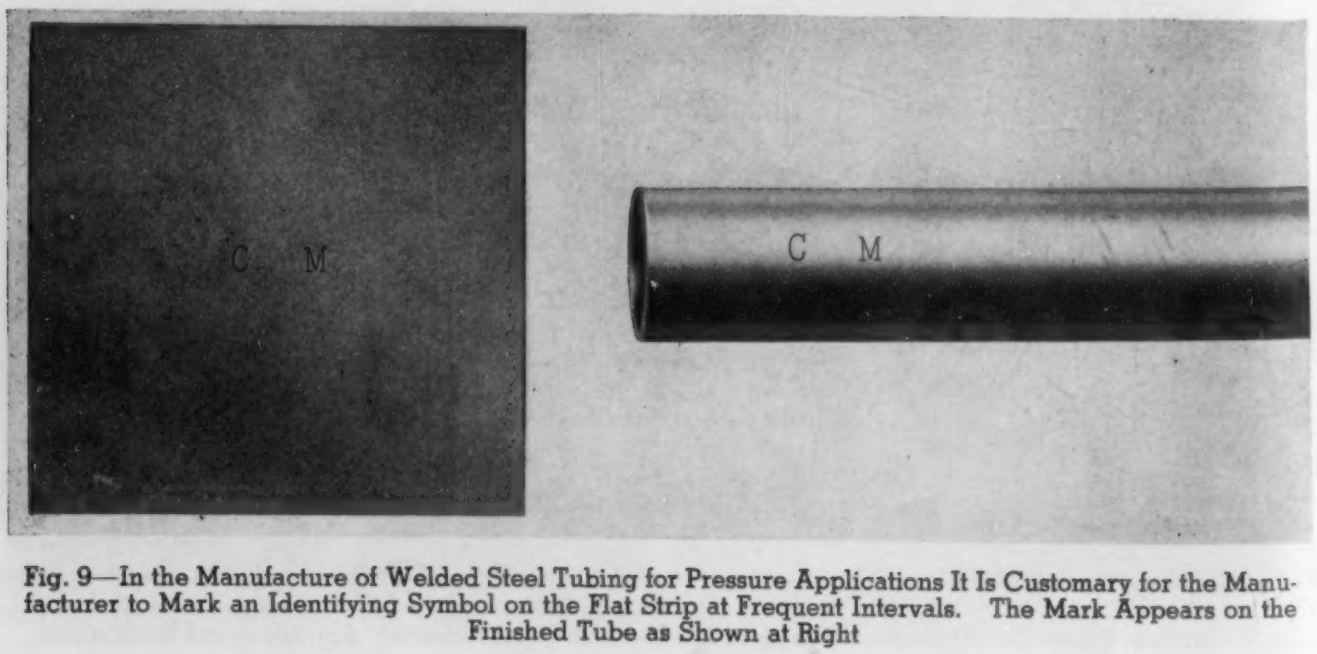


Fig. 9—In the Manufacture of Welded Steel Tubing for Pressure Applications It Is Customary for the Manufacturer to Mark an Identifying Symbol on the Flat Strip at Frequent Intervals. The Mark Appears on the Finished Tube as Shown at Right

as a group, realizing that the reputation of its products, in general, may rest upon the quality produced by any one of the individual mills.

The first length of tubing from each coil of steel is tested immediately to determine the characteristics of the weld, and all tubing from the coil is rejected until a satisfactory product is being produced. Intermediate tests are taken at intervals as required, and a complete log kept of the complete run of tubing. These routine check tests are generally severe enough to assure that the tubing will pass all subsequent tests that may be required by specifications.

It is also of interest to note that some of the processing operations which follow the welding and sizing constitute very severe tests of the structural integrity of the entire tube wall. In particular, the cold drawing operation and the straightening operation are two which involve stressing the metal beyond the yield point.

When the tube is drawn through a die it is subjected to longitudinal tensile stresses and to both radial and circumferential compressive stresses. This combination of stresses is accompanied by shearing stresses in the material of the tube that are considerably higher relative to the longitudinal tensile stress than is the maximum shearing stress in a bar subjected to simple tension. The fact that the weld area is able to undergo the very considerable changes of dimension involved in drawing is very practical evidence of correct welding procedure.

The equipment employed to straighten the finished tubing consists of two sets of concave rolls with their axes inclined to the horizontal axis of the tubing, causing the tubing to rotate while moving forward, due to the spiral motion imparted to the tubing by the rolls.

The first set of rolls is adjusted to bend the tubing beyond its yield point to a definite degree of bend, while the second set compensates for this deflection, resulting in a straightening of the tube. As the tubing progresses through each set of rolls the weld is subjected to an alternation of stress twice during each revolution, with varying degrees of shear and torsion added.

The magnitude of these stresses exceeds the yield point of the steel and an appreciable change in length occurs. This is a unique situation in the testing of welds, wherein a welded product is stressed beyond the yield point of the steel continuously throughout the full length of the weld, and still the tested article remains within mechanical tolerances.

The straightening operation is highly effective in detecting weak welds, because the tubing is stressed at times close to the ultimate strength of the parent metal. Any welds failing in the straightener are detected through internal pressure testing, electrical testing or by visual inspection.

Special tests are devised to duplicate as closely as practical the operations the tubing is to be subjected to in fabricating and service, using an ample factor of safety.

Man is born with various organs for detection through sight, taste, hearing, smell and touch but no single organ can govern the whole sensory range. Likewise, we have many devices and processes for determining various facts pertaining to our welded product, each one of which is excellent within its limitations but not one of these can be applied universally.

Given a full understanding of the requirements for a given application of steel tubing together with a knowledge of the changes in characteristics resulting from the various methods of processing, and with proper testing equipment and methods to determine the quality of the finished product, all under a competent process engineering head, the problem of quality control becomes largely one of simple mathematics and eternal vigilance.

The general acceptance of and high regard for electric-resistance welded steel tubing today is a glowing tribute to this system of maintaining quality.

Applicable Methods of Inspection for Pressure Vessels and Piping*

By Wm. D. Halsey†

THE available methods of inspection of welding, namely, visual, radiographic, sampling and magnetic powder are all applicable, in at least some degree, to pressure vessels and piping. In fact, some of these methods are mandatory in the widely recognized construction codes such as the A.S.M.E. and the A.P.I.-A.S.M.E. Pressure Vessel Codes. Except for the specific requirements of such Codes, any decision as to what method of inspection should be followed must be based on the nature of the information desired.

It may be presumed that the principal objective in the inspection of welding is to determine that the weld is sound and by that is meant that the welded joint has satisfactory penetration, is well fused and is free from objectionable or harmful slag inclusions, cracks or porosity. It is, of course, necessary that in some way it be determined that the weld metal is of satisfactory tensile strength and ductility and that the base material has not been injured by the process of welding. Information of this nature can best be determined by the adoption of proper welding practices that have been developed by proper research or by long usage so that experience has shown them to be satisfactory. The weldability of the base material should be known and the suitability of the electrode to be used must be well established. In many instances, such as in the case of the construction codes previously referred to, it is necessary that the fabricator establish his method of welding, giving consideration to all essential variables, and that a

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test then be made to determine that such method may be expected to give welded joints of acceptable tensile strength and ductility. In some cases, for instance in the A.S.M.E. Boiler Code and for certain types of vessels in the Unfired Pressure Vessel Codes, specimen welds must be made and tested for each vessel.

The developments in metal arc welding that have taken place in the last decade are such that there now exists a rather extensive knowledge of what constitutes good welding practice to obtain weld metal of satisfactory tensile strength and ductility and to avoid injury to the base material, so that inspection of welding today is focused not so much upon the question of tensile strength and ductility as it is upon the soundness of the weld.

The visual method of inspection for soundness of welds is applicable primarily only while the weld is being made. While the contour of a finished weld may furnish some information regarding its probable soundness provided, of course, that there is definite knowledge of the manner in which the parts were prepared for welding, such surface inspection cannot be expected to give any positive knowledge of the soundness of a weld. Unfortunately, a weld that "looks all right" on the surface may be a very unsound one.

Visual examination of a weld as it is made affords an opportunity to determine that the parts have been properly prepared for welding, that acceptable materials are being used, that the welding operator is keeping the weld free from serious slag inclusions and that the weld is being fused to the base material. It has been shown that the visual method of inspection is productive of very reliable results provided competent welding operators are used, the inspector is capable and the inspection is extensive enough to watch every inch of the welding. Such inspections, sometimes referred to as "man to man inspections" require an inspector for every welding operator and are thus expensive. On the other hand, a somewhat less exacting program of inspection but based upon the use of competent welding operators as determined by test, supervision by competent foremen and check inspections from time to time to see that proper practices are being followed has been productive of a grade of welding that has proved itself reliable for a great many classes of service.

The radiographic inspection of welding may be carried out by the use of X-ray or by gamma-ray. The former is accomplished by the use of an X-ray tube and the latter by the use of a capsule of radium or of radium emanation.

The X-ray method is most generally applicable in the shops of manufacturers of pressure vessels although some X-ray examinations have been made in the field. However, such application of the X-ray method in the field is limited because of the bulk of the equipment involved. On the other hand, the gamma-ray method involves equipment of relatively small bulk.

The radiographic method of inspection is most suitable on butt welds where both sides of the weld are readily accessible. The method is less applicable to welds attaching nozzles to shells.

Either method of radiographic examination as commonly used, furnishes a record on a photographic film and the principle of either one is that any defect such as a slag inclusion, porosity, certain types of cracks and serious lack of fusion do not absorb the penetrating ray to the same degree as solid weld metal or the base material and thus these defects are shown on the film as dark areas. The interpretation of such evidences on the radiographic film is not too difficult to make but does require some degree of experience.

It appears that there has been some tendency to view radiographic methods of inspection as being quite complete. On the other hand, it is believed that all those who have had experience with this method of examination will agree that there are certain types of cracks or lack of fusion that are not detected by X-ray examination as ordinarily applied. With particular reference to cracks it should be understood that the plane of the crack must be parallel to the penetrating ray or, at least, nearly so. Fortunately a crack that is of any depth in a butt weld will usually be in that plane and can, therefore, be detected by radiographic examination although careful radiography is necessary as is also close examination of the radiographic film.

The sampling method of inspection of welding may be carried out either by the trepanning of plugs or by the removal of a boat-shaped specimen as is accomplished by the use of equipment known as a "Weld Prober."

Either of these methods removes samples from the welded seams at selected points. These may be locations that are definitely under suspicion or they may be selected at random to get an idea of the average quality of the weld or to exert a physiological pressure upon the welding operator that any part of the weld that he makes may be so examined. Of course, when used in this manner the welding operator should know in advance that such an examination will be made of his welds.

When plugs are removed by trepanning, the hole so made is sometimes closed by a threaded plug which may be seal welded for tightness if so desired or a plug may be welded into the hole. There has been some objection to this method of examination when the hole is closed by welding as some have felt that severe stresses are set up by welding in a constricted place.

The boat-shaped specimen removed by the weld prober provides material that can be tested in several ways such as for soundness, for tensile strength and for ductility. The opening left in the weld is similar in many respects to a welding groove and thus lends itself readily to rewelding without great difficulty.

The magnetic powder method of inspection involves the magnetizing of the portion of the weld to be examined and then applying a suitable paramagnetic powder, such as iron filings, to the surface. When the part to be examined is properly magnetized the powder will gather at any crack that extends to the surface and may also, by a similar indication, reveal subsurface defects provided they are not too far below the surface and provided they are of sufficient magnitude to provide the magnetic field at the surface which will hold the powder in contact with that surface.

Inasmuch as cracks which develop in welds as they are being made are one of the most serious types of defect that may be encountered and are frequently difficult to detect except upon a most minute examination, the magnetic powder method of inspection is valuable for use as a weld is being made to insure that no cracks exist in a given layer of welding before the subsequent layer is deposited. In many instances this method of inspection has been used for each layer of welding as applied, and where radiographic methods were not available, and in many instances cracks have been found which were repaired before further welding was done.

As our experience with welding and its application to more extensive fields increases the probability of defective work decreases provided, of course, that those who use welding understand its fundamental principles and what must be done to insure good work. This means further that intelligent foremen and supervisors are necessary and that honest and competent workmen are employed to do the work. Where such intelligence and honesty are applied inspection becomes less necessary than in the case where slipshod methods and shortchange practices are the vogue.

The Welded Locomotive Boiler*

By E. G. Young†

THIRTY years ago as a graduate student I first encountered the problem of locomotive boiler design in terms of inches and pounds, whereas I had previously known it in terms of heat transmission, and for many years later as a practical worker in this field the problem continued to haunt me. I was even an accessory to turning down a million-dollar order for a foreign railway because we could not quite "make the weight"—the figures perversely insisted that the engine would weigh a thousand pounds more than the maximum which the purchaser wanted. The boss had a perfectly philosophical solution for this impasse: "Leave the right cylinder off—that will save 7000 lb." His experience told him that we could scrimp and trim no further, and a competitor built the order to quite other specifications. That extra weight in the boiler must have been cursed numberless times by locomotive engineers, and I suppose for a generation or more they have been looking longingly at advancement in the welding art, as they thought of welding in relation to their own "skimp and trim" problem.

The locomotive boiler is a problem of a vessel on which are imposed fairly simple and determinate direct stresses, but in which necessary variations in form from part to part result in constructions at times approximating patch work where the rectangular firebox section is joined to the cylindrical barrel. Figure 1 shows a general view of a typically constructed locomotive boiler, though one designed beyond the usual range of size. The figure clearly shows the large measure of overlapping plates and the telescoping of the shell sheets and the first shows the excess of metal in the throat sheet which connects the firebox end with the barrel. This will indicate to you in part the nature of the boiler designer's problem; also the projection of the hundreds (or thousands) of flexible stays with the excess weight necessary for their spherical sockets and caps points the other prime problem: the provision of staying for flat or nearly flat surfaces subject to steam loading.

The sectional drawing of the same boiler shown in Fig. 2 will further illustrate some of the difficulties, since it shows the various liners, welt strips, etc. In passing it should be noted that the welt strips *could* be made smaller, but this will involve a less efficient longitudinal seam, and consequently additional thickness of barrel plates. The use of a seam with 6 rows of rivets (3 each side of the opening in the original plate) results in seam efficiencies around 85%; the use of 5 rows each side will permit efficiencies approaching 95%; shell-plate thickness and weight obviously vary inversely with these figures. The increased welt-strip area will "eat up" in such a case most of the attractive saving which is apparently to be had from the use of the higher efficiency.

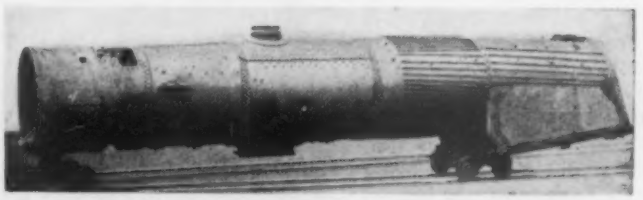

Fig. 1—General View of Large Locomotive Boiler of Riveted Construction

Figure 3 shows the construction of the internal firebox and combustion chamber of a boiler similar to that for which previous pictures have been given. The plates are drilled for the reception of the staybolts that hold the surface in place when carrying steam pressure loading. That is, they hold it approximately in place, for especially during the process of raising steam, and more or less under all conditions of operating, there is movement relatively between the inner and outer shell. At the end of a long combustion chamber as shown in Figs. 2 and 3 movements approximating an inch have been observed. Under such conditions the impossibility of staying inner and outer shells rigidly together becomes obvious. The socket-mounted "flexible" staybolts are the answer to this problem, as far as compensating for the movement goes, but they present a weight complication which is increasingly serious. "Well, if you are crowded by weight limits, merely put a smaller boiler on and have all the leeway you wish for design details." This sounds well, but has a weakness, in that boiler efficiency and capacity are contrary considerations.

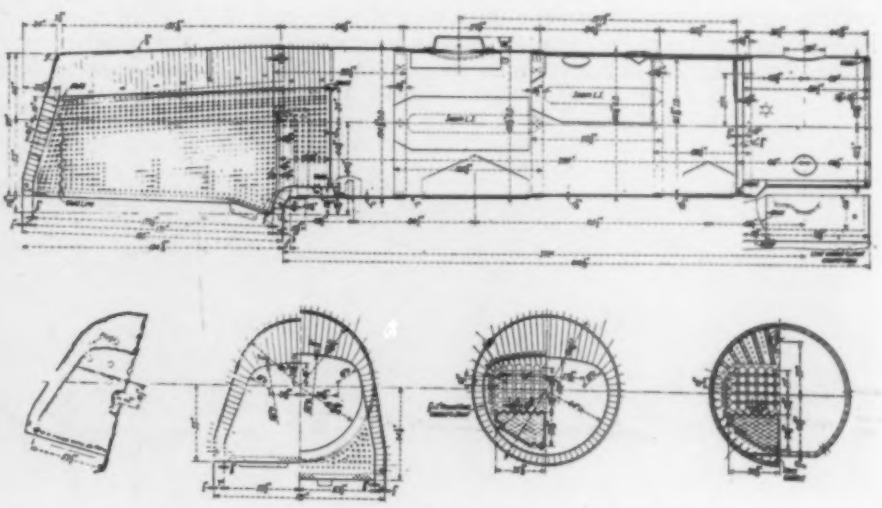

Fig. 2—Elevation and Cross Sections of Riveted Boiler

* To be presented at the Annual Meeting, A.W.S., Chicago, Ill., Oct. 18 to 21, 1943.

† Professor of Railway Mechanical Engineering, University of Illinois, Urbana.

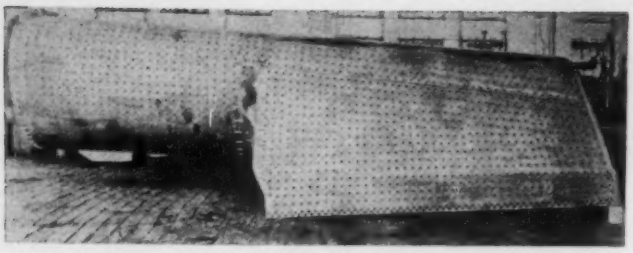

Fig. 3—Inside Firebox Structure, Entirely Fabricated by Welding

For any required output, steam can be produced most efficiently in the largest possible boiler. Thus any curtailment of boiler capacity is at the same time a reduction of efficiency, and, *per contra*, within the weight limits available, the boiler with the largest possible heat transfer capacity gives the most efficient locomotive.

I have pointed out to you that the more efficient the seam, the less may be the thickness of the shell plating. The Interstate Commerce Commission stipulates that with boiler steel taken as having a tensile strength of 55,000 psi., the factor of safety against bursting due to radial pressure must be 4.5. That is, taking a ring of boiler shell 1 in. long with load (diameter × pressure) $D \times P$, and carrying capacity ($2T \times t \times e$), twice the unit tensile strength × the thickness and the efficiency of the seam, the carrying capacity ÷ load must be 4.5 or more. Algebraically $2T \times t \times e/(D \times P) = 110{,}000te + DP = 4.5$. If we consider the efficiency as 82% for the purpose of simplification, $t = PD/20{,}000$, a convenient "rule of thumb" from which modifications for actual efficiency are readily made. Suppose we have a shell 16 ft. long and 80 in. in diameter, with a working pressure of 250 lb., the thickness required is $PD/20{,}000 = \frac{80 \times 250}{20{,}000} = 1.0$ in., or if a 90% seam may be used the thickness will be 29/32 in. The weight of $^1/_{32}$ in. of thickness on the assumed shell would be nearly 430 lb. or 2.25 lb. per inch of shell length. Suitable welt strips for the 82% seam would weigh 6 lb. per inch of shell length while for the 92% seam the welt weight would be 11 lb. per inch. In the example cited, the use of the more efficient seam permits a saving of 4/32 in. thickness or 1300 lb., at the expense of increasing the welt-strip weight 182 (11 − 6) = 910 lb., which is generally illustrative of the numerical values involved.

I have no photograph which shows the lapping of plates along the flanges of the inside firebox structure and there are good structural reasons for this lack, but taking measurements from the drawings of a firebox of similar general form and size to those which would correspond to Figs. 1 and 2 it is found that there is a double thickness area of nearly 16 sq. ft. Figure 3 shows such a firebox of welded construction. But only in an occasional and somewhat gruesome picture of an exploded boiler can you get a real idea of the appearance of the structure in its relation to the outer shell. It reminds one of a porcupine with its hundreds of staybolts protruding radially or normally on all sides, a supporting bolt for every 16 to 18 sq. in. In general, to give these bolts necessary area for carrying their normal tension load, and to make it possible to put them in place by screwing in, they have undesirable stiffness and excess strength (and weight) to oppose the lateral strains imposed by the relative movement of inside and outside sheets. If these flat-surface stays could be designed as rectangles with the short axis parallel to the longitudinal center of the boiler, they could have adequate strength in tension combined with flexibility sufficient to require the use of only a few of the socket-head stays now installed at the points of greatest relative motion. Lest this sound as if I were claiming originality, please note Fig. 4 herewith. This is the Jacobs Schupert firebox of 35 yr. ago, a construction peculiar to the Santa Fe Railway, to the best of my knowledge. The slide makes the arrangement

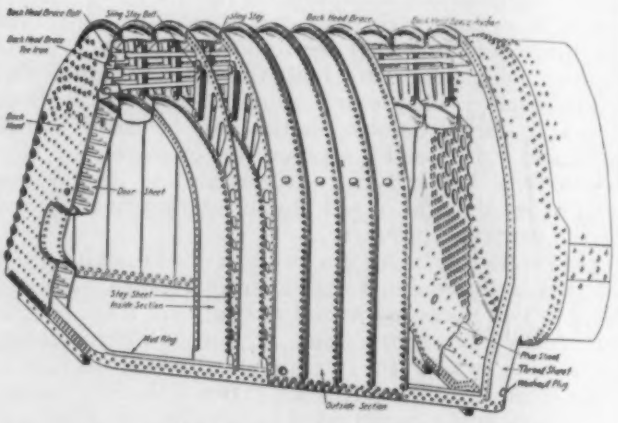

Fig. 4—Jacobs-Schupert Sectional Firebox 1913

quite clear: the firebox consisted of two sets of channels riveted flange-to-flange, one set forming the outer shell, one set making the inner firebox. A pair of channels plus a spacing plate made up a unit of the length of the firebox; the spacing plate held the inner and outer firebox in proper relation and provided the necessary flat surface bracing to give the crown sheet or top of the inner firebox the necessary stiffness. You may note that the arched construction of the top of the firebox reduced the number of radial stays and waterspace stays from hundreds to scores, and they were flexible in the right

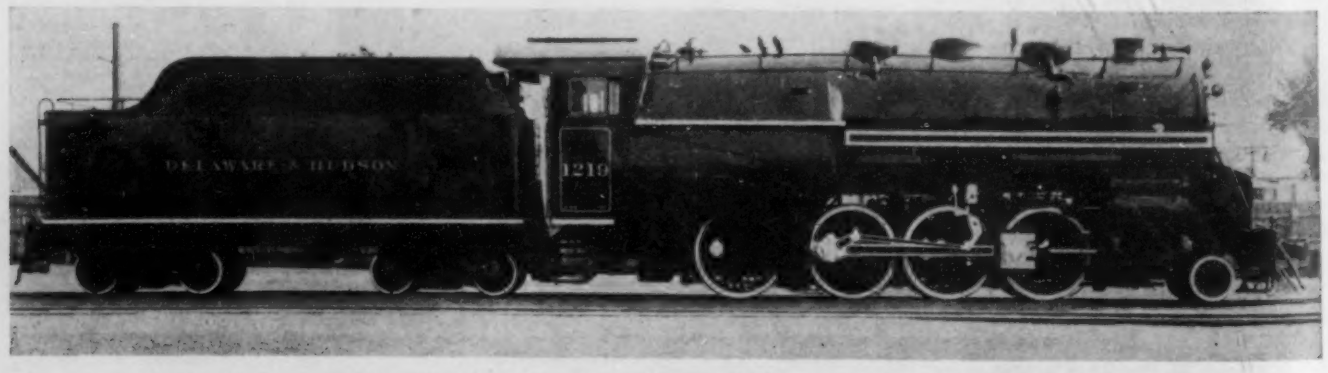

Fig. 5—Delaware & Hudson Ry. Class E-6-s 280 Locomotive Fitted with All-Welded Boiler

direction, as well. This construction was abandoned after a brief time, however, due to cracking the smallest radius of the bends in the channels.

I have gone to considerable length in attempting to set out clearly the inviting field for welding in the locomotive boiler. For many years the process was used to a limited degree, but hampered by the I.C.C. ruling which permitted no assignment of strength to welded joints. Under this limitation the greatest advancement attained was the electric welding of the firebox sheets throughout, as shown in Fig. 3.

We have no way of determining how long it was that the designer, faced by the eternal "cut and trim" problem resulting from the continual increase in steam demand and consequently boiler size on the one hand, and a growing sensitiveness to weight limitations on the other, indulged in his dreams of eliminating excess metal. We boys talked about it in 1913 but knew the state of the welding art at that date made it a "pipe dream." But as welding came into its proper applications in the railway construction and repair shop the day of the welded boiler was inevitable.

I shall quote a few lines from the Report of the Committee on Autogenous Welding and Cutting to the Convention of the Mechanical Division of the Association of American Railways in June 1937. "Progress in autogenous welding and cutting the past year has been marked by notable introductions of new apparatus and applications. Autogenous welding and cutting meet the three factors of industrial and railroad design: appearance, cost and durability. Today's demand is for better products and equipment, straight lines and stream lines . . . . From the railroad standard of fabrication one of the most notable developments of recent years is the development of an all-welded locomotive boiler. Lack of facilities in the railway shop to do this kind of work as required by the code of the A.S.M.E. for power boilers resulted in little interest formerly being shown in this type of work . . . and because of this situation the Bureau of Locomotive Inspection of the I.C.C. has given no indication that it would permit the operation of all-welded boilers in Interstate Commerce. In fact they have been opposed to the all-welded construction. This change in sentiment (increasing interest

Fig. 6—The All-Welded Boiler, Right Side

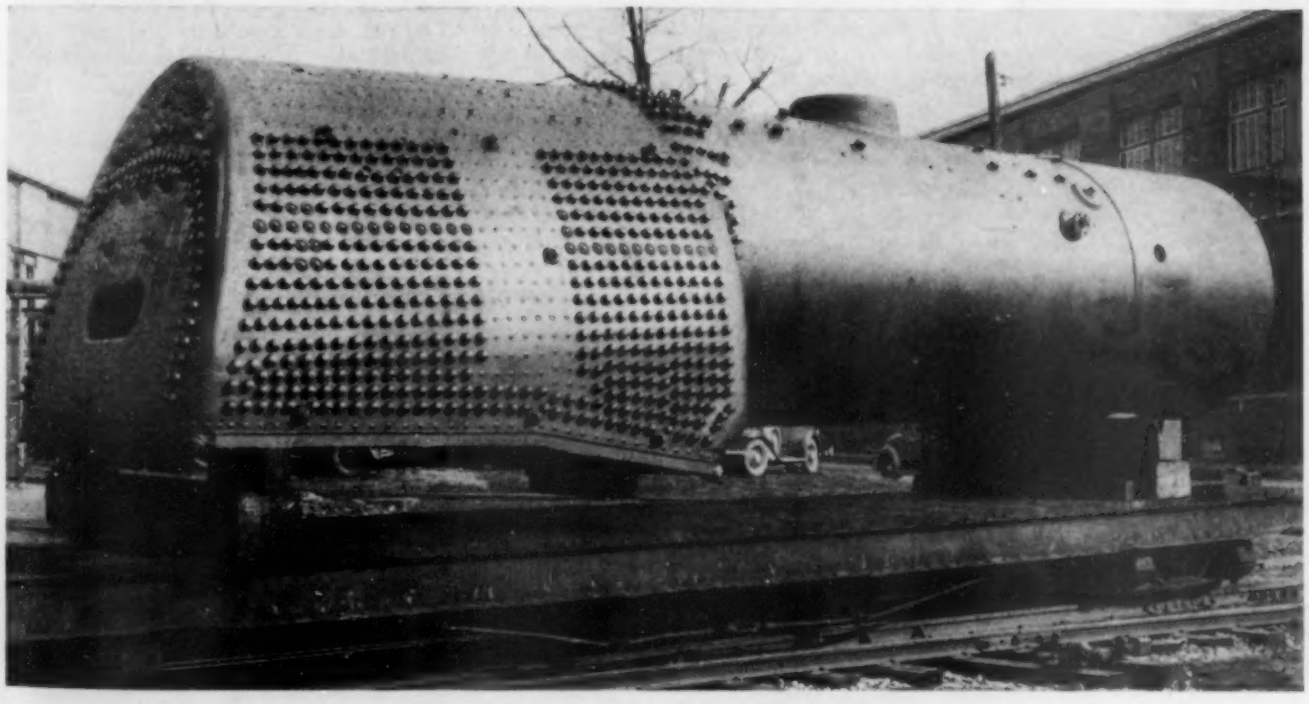

Fig. 7—Same as Fig. 6 Showing Back End

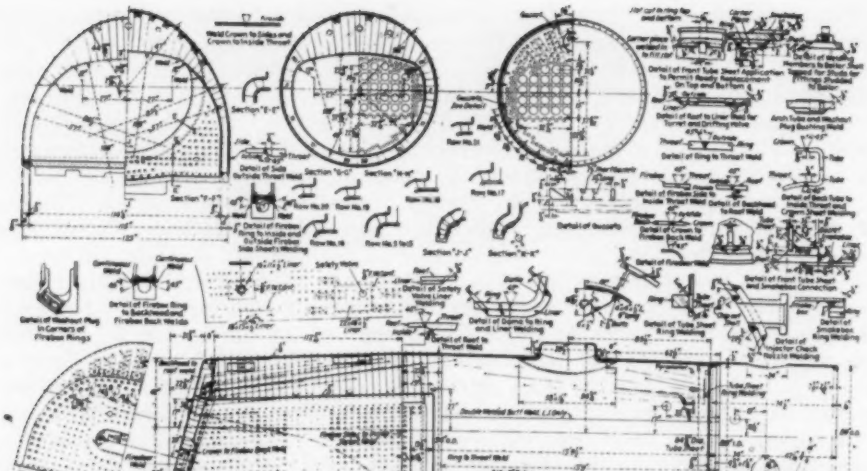

Fig. 8—General Drawing of the All-Welded Boiler

among the railroads) has been recognized by the I.C.C., and they agreed to the construction and operation of an experimental all-welded boiler. The design was first reviewed and approved by the Locomotive Design Committee (of this same division) and permission for construction was granted under the condition that the boiler was first to be tested under actual operation for six weeks as a stationary boiler before being put into road service."

The purchaser, extending this provision, used the engine in yard service for six months in addition before it was placed on the road. The locomotive for which this boiler was designed was a standard Delaware and Hudson 2-8-0 weighing 300,000 lb., making it one of the heaviest designs of this type there is in service. The cylinders are 27 x 32 in., the driving wheels 63 in. in diameter, and the working pressure of 225 lb. results in a tractive force of 70,800 lb. The boiler is of the conical shell type, with a diameter (outside) increasing from 88 to 94 in. in the $166\frac{1}{2}$-in. length. The plate from which the shell was formed was practically 25 x 15 ft. An efficiency of 90% was assumed for the welded longitudinal joint, which for a pressure of 225 lb. $91\frac{7}{8}$-in. inside diameter, and $1\frac{1}{16}$-in. plate thickness results in a factor of safety of 5.03. Following the usual practice of the D. & H., this engine has a very large firebox derived from the "Wootton" firebox design, for burning anthracite or anthracite mixture. The grate area is 104.4 sq. ft., $9\frac{1}{2}$ x 11 ft. This requires, as the picture shows, that the cab be placed entirely behind the firebox. The boiler itself is shown in Figs. 6 and 7. Note its smooth outside as compared with the all riveted boilers of earlier figures, marred only by the "warts" representing the flexible staybolts. Figure 8 shows the boiler general drawing. In this the butting of the sheets and the elimination of double and triple thicknesses of metal show clearly, both in the shell sheet and the firebox construction. The attachment of the dome is of special interest: the flanged dome plate is let into an opening in the top of the shell and butt welded. The necessary additional strength to compensate for the dome opening in the shell is secured by the use of a liner covering the circular seam, and flanged to fit snugly against the inside surface of the flanged dome sheet. The firebox shows two considerable differences from conventional construction, the butt welding of the sheets (which is not a novelty), this having already been shown you on another boiler) and a foundation ring construction devised for this engine, the foundation ring itself (which is not a "ring" in any usual sense) being shown in Fig. 9. This piece is normally made of rectangular section and is a frame which holds the lower ends of the inside and outside firebox sheets the proper distance apart; the sheets are riveted to the "ring" with a double row of rivets. In the present case, the "ring" has flanges at its top, and the bottom row of water space staybolts passes through the two sheets and the two flanges, tightness being secured by a light seal weld.

The boiler construction requires examination from two standpoints. Is it serviceable? The answer to this is reflected in the regular inspection reports, which have been pleasantly monotonous in their regularity "no defects have developed," "all seams tight," "not a simmer," for, month after month and year after year, through the preliminary months as stationary boiler, through the yard service period and years on the main line. The question of construction expense cannot receive any important contribution from the results of building a single experimental boiler and must be held in abeyance for the answer determined from the normal and regular construction of this type of boiler.

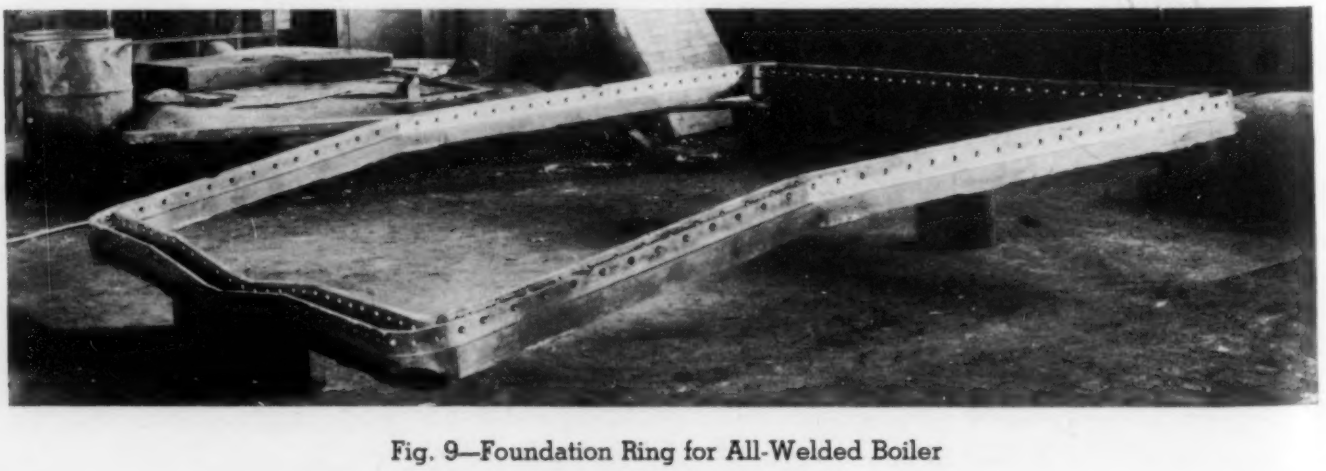

Fig. 9—Foundation Ring for All-Welded Boiler

The question of weight saving has several phases. Through the courtesy of the builder I have been furnished with the statement that the welded construction saved 2178 lb. of metal. This I interpret to mean that a boiler of the identical dimensions but with normal riveted construction would weigh 2178 lb. more. From the drawing of the boiler it is clear that the shell sheets would have to have a combined length of at least an additional foot to accommodate the conventional throat construction, which would probably require that there be two shell sheets with the usual lap joint. With this construction the entire slope would be in the first course. Using a 90% seam the plate, with 94 in. largest external diameter, would be (with 4.5 factor of safety) $^{31}/_{32}$ in. thick. This plate would weigh 7244 lb. The second shell course would require $^{31}/_{32}$ in. thickness, would be uniformly 92 in. inside diameter, and allowing for a lap joint with the first sheet and the usual type of throat-wrapper-sheet-course joining would have an average length of 84 in., thus weighing 6697 lb. with 30-in. dome hole deducted. The welt strips at 11 lb. per inch would require 1650 lb., if it is assumed that the dome liner serves as welt for the second course. Thus the total shell weight is 15,591 lb. The throat seam connection to the second course would result in an overlap of 9 sq. ft. of throat material or say 410 lb. properly chargeable to the shell, making a total weight of 16,001 lb. The shell sheet of the welded boiler is $165^1/_2$ in. long and has an average neutral axis diameter of 91 in. Thus it weighs with dome hole deducted and mill allowance added, 14,300 lb. Thus the shell sheets compared save 1700 lb. by the welded construction in spite of the specified factor of safety of 5 in place of the usual 4.5. The saving in plate lapping on the firebox is 13 sq. ft. for the wrapper sheets, and 17 sq. ft. on the crown sheet; that is 340 and 320 lb., respectively. There is also a weight of 300 lb. of extra metal in the connection between the course and the wrapper, which would be absent for the conventional construction. Hence the total saving for the welded construction is 1700 lb. in the barrel sheets, 660 lb. in the plate lapping around the firebox, less 300 lb. extra metal in the connector section, a net value of 2060 lb. and a presentable check with the builder's figures (2178 lb.).

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THE AMERICAN WELDING SOCIETY

ACTIVITIES — RELATED EVENTS

OUR PRESIDENT

David Arnott

Mr. Arnott, who has served the AMERICAN WELDING SOCIETY as its Second Vice-President for two years, and First Vice-President for one year, has been elevated to the position of President of the SOCIETY.

David Arnott

Mr. Arnott has been active in the SOCIETY since its early days, particularly in its technical activities relating to ship welding. He has delivered a number of papers before the various Sections of the SOCIETY and was author of an important chapter of the first edition of *Welding Handbook*. Mr. Arnott served as Chairman of the Committee preparing the Chapter of the new 1942 edition of the *Handbook* on Ships. Mr. David Arnott has been a strong supporter of the research activities of the SOCIETY and at the present time is Chairman of the A.W.S. Committee on Welding in Marine Construction. He has also served on the Executive Committee of the SOCIETY.

Mr. Arnott was born in Glasgow, Scotland in 1878. He is a graduate of the Royal Technical College, Glasgow, and received his apprentice training in ship construction with the Fairfield Shipbuilding & Eng. Co., Ltd., Glasgow. He served as Surveyor, British Corporation Register of Shipping and Aircraft from 1901 to 1917, at head office in Glasgow. He was also Principal Surveyor for Canada, British Corporation Register of Shipping and Aircraft, from 1917 to 1918, stationed at Toronto. Later he became Deputy Chief Surveyor, American Bureau of Shipping, from 1918 to 1925, New York. In 1925 he became Chief Surveyor of the American Bureau of Shipping, a position which he holds at the present time. To these duties were added those of Vice-President of the American Bureau of Shipping in 1938, which position he also now holds.

His technical society affiliations are quite numerous and include: Council Member, Society of Naval Architects & Marine Engineers; Member, Institution of Naval Architects; Member, British Institute of Welding; Technical Adviser to U. S. Delegation, International Safety of Life at Sea Convention 1929; U. S. Delegate to International Load Line Convention 1930. Mr. Arnott became a naturalized citizen of the U. S. A. in 1924.

The Miller Medal was awarded to Mr. Arnott in 1941 for conspicuous contributions to the art and science of marine welding.

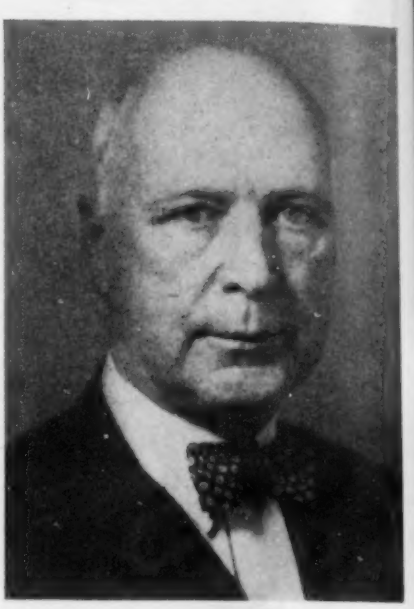
The Bureau of Shipping, with which Mr. Arnott has been associated for the last 23 years, has played a prominent part in the application of welding to ship construction. This application was one of gradual evolution, whereby welding at first was used in assembling parts of the ship which were not of importance structurally. In 1927 the American Bureau of Shipping made possible full classification for all-welded vessels, the first classification society in the world to do so.

OUR FIRST VICE-PRESIDENT

Isaac Harter

Mr. Isaac Harter, now vice-president of the Babcock & Wilcox Company, Barberton, Ohio, was born at Mansfield, Ohio, in 1880. He graduated in 1901 from the University of Pennsylvania with the degree of B.S. He began work that year in the Boiler Department of Aultman & Taylor Company at Mansfield. In 1905 the Stirling Company at Barberton, Ohio, bought the business at Mansfield and in 1906 it was in turn acquired by The Babcock & Wilcox Company, by whom he has been employed since that time in various capacities in manufacturing, plant construction and technical and business development.

His interest in welding began with experiments in 1907 in repairing steel castings with a carbon arc. From 1911 to 1914 he was instrumental in investigating several serious cases of caustic embrittlement, and, as a result, brought about a radical change in boiler water treatment in the U. S. N. and a general interest in the modifying effects of sodium sulphate in these cases. His company made use of bare wire welding in boiler drums from 1922 to 1929 at the ends of the main longitudinal seams and then led the way in the manufacture and sale of completely welded boiler drums. He was closely associated with the beginnings of the A.S.M.E. Boiler Code and the corresponding Code of the State of Ohio, and with the acceptance by the U. S. N. of welding for its pressure vessels. In 1931 he became responsible to his company for the construction and installation of the thirty-foot penstocks at Boulder Dam, a project impossible to realize without the art of welding. He has guided the development of its business in kaolin refractories, in the production of alloy steels for its own use, and more recently for its work in the production of electrically welded tubes.



Isaac Harter

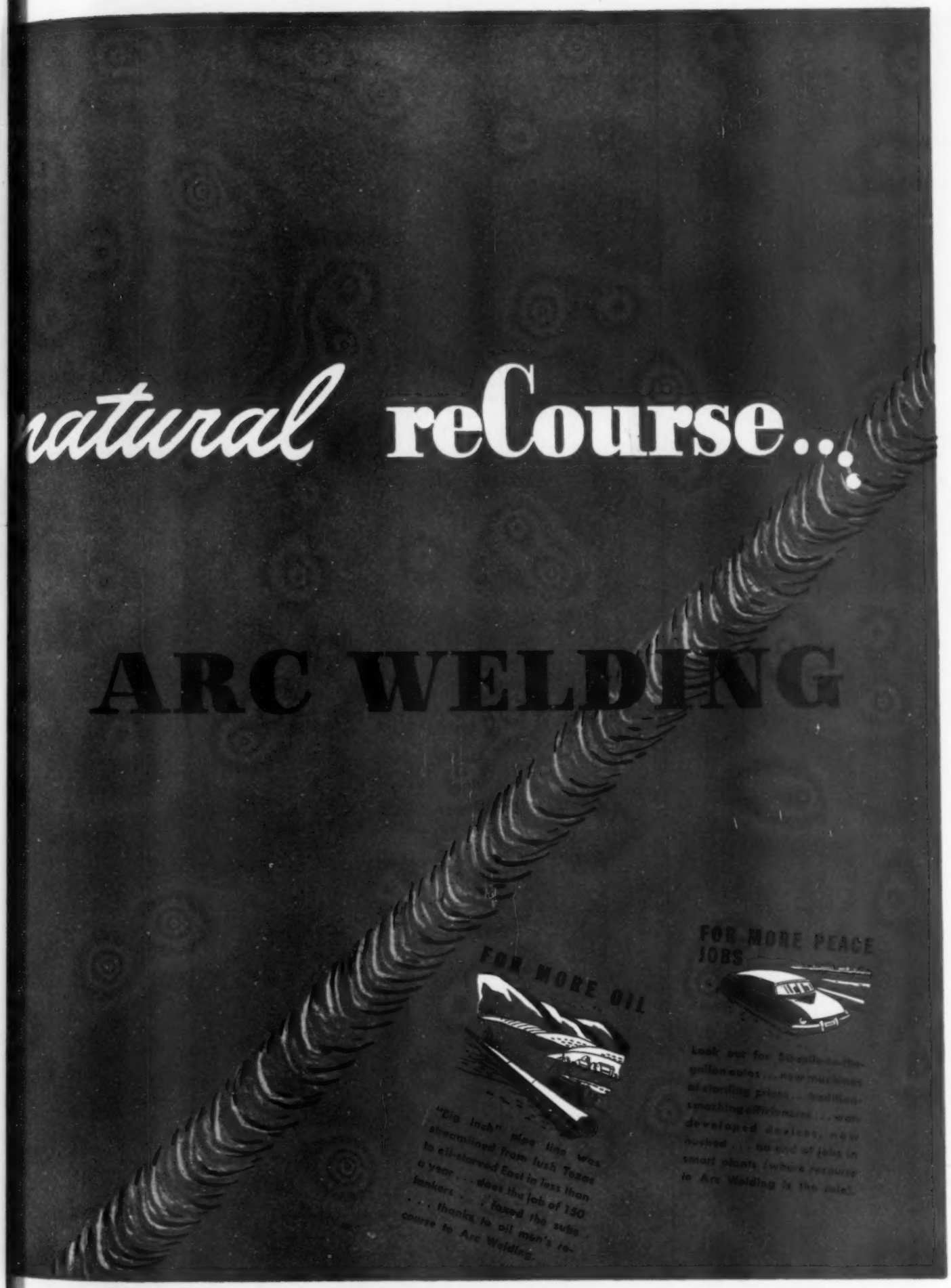
OUR SECOND VICE-PRESIDENT

A. C. Weigel

"Al," as he is known to all of his friends, was born July 13, 1887. He graduated from the University of Tennessee in 1908. He joined the Walsh & Weidner Boiler Co. and remained with them until its acquisition by Combustion Engineering Co. in 1928. He has been with the latter organization ever since. At present he is Vice-President of this company.

Mr. Weigel, in addition to being a member of the SOCIETY and its Executive Committee, is also a member of the A.S.M.E. Boiler Code Committee, Newcomen Society and other technical societies.

During the past two years Mr. Weigel has served as Chairman of the Publications Committee of the SOCIETY.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ARC WELDING
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"Big Inch" pipe line was streamlined from lush Texas to oil-starved East in less than a year . . . does the job of 150 tankers . . . fooled the subs . . . thanks to oil men's recourse to Arc Welding.
FOR MORE PEACE JOBS
Look out for 50-gallon-the-gallon cars . . . new machines at startling prices . . . bodies—something different . . . war-developed devices, now pushed . . . no end of jobs in smart plants (where recourse to Arc Welding is the rule).

Recourse: According to Webster, *"a going to for aid or protection"*

A. C. Weigel

"Al" Weigel possesses rare judgment and tact and is an outstanding executive. He is keenly interested in welding matters and in the SOCIETY. He is active in the work of the Welding Research Council and is a member of its Executive Committee. He is also active in its financial affairs.

OUR DIRECTORS-AT-LARGE

Harry W. Pierce

Harry W. Pierce was born in Syracuse, Neb., Sept. 30, 1901. He was graduated from the U. S. Naval Academy in 1922, commissioned Ensign, U. S. Navy, and served two years in Destroyer Squadrons, Battle Fleet. He was transferred to the Construction Corps, U. S. Navy, in 1924, and was ordered to postgraduate instruction at the Naval Academy and Massachusetts Institute of Technology, receiving M. S. degree in Naval Construction in 1926. Following duty at the Philadelphia Navy Yard as Assistant Hull Superintendent, and as Assistant Superintending Constructor, U.S.N., at the plant of the New York Shipbuilding Corp., he resigned in 1930. Since Oct. 1930 Mr. Pierce has been with the New York Shipbuilding Corp. in various capacities: Assistant General Foreman, Hull Department; Welding Supervisor, Welding Engineer and, at present, Assistant to the General Manager.

He became interested in welding in shipbuilding while at M.I.T., and for his degree a prepared thesis on "Effect of Welded Attachments on Strength of Longitudinal Members." Since 1931 he has been principally occupied with welding development in ship construction, including design, specifications, procedure control and training. He is a member of the Society of Naval Architects and Marine Engineers and AMERICAN WELDING SOCIETY. He has presented various papers before both societies, and has served on several committees. At present he is serving second term as Chairman, Philadelphia Section of A.W.S. Mr Pierce is Chairman of the Thermal Stress subcommittee of the A.W.S. Marine Committee.

Harry W. Pierce

* * *

Eric R. Seabloom

Eric R. Seabloom was born in Vesteros, Sweden, on October 16, 1899, and came to the United States in 1909. He attended

INDEX TO ADVERTISERS

Air Reduction Sales Co.	Outside back cover
American Brass Company	829
American Chain & Cable Company, Inc.	831
American Optical Co.	851
American Welding Society	884
Ampco Metal, Inc.	877
Anti-Borax Compound Company	842
Arcos Corp.	Inside front cover
Bastian-Blessing Co.	848
Carnegie-Illinois Steel Corp.	855
Champion Rivet Co.	843
Chicago Bridge & Iron Co.	873
Electroloy Co., Inc.	856
Emerson Electric Mfg. Co.	841
Eutectic Welding Alloys Co.	852
Foote Mineral Co.	871
Frostrode Products	839
General Electric Co.	Insert 882 & 883
Glenn-Roberts Company	840
Golden Rod Equipment Company	836
Handy & Harman	857
Harnischfeger Corporation	847 & 880
Hobart Bros. Co.	765
International Nickel Co., Inc.	849
Kelley-Koett Mfg. Co.	875
The Lincoln Electric Co.	832 & 833
The Linde Air Products Company	767
P. R. Mallory & Co., Inc.	838
The McKay Company	863
Metal & Thermit Corporation	878
National Carbide Corporation	854
National Metal Congress	837
Oakite Products, Inc.	848
Page Steel & Wire Division	831
Picker X-Ray Corporation	867
Ransome Machinery Co.	846
Reid-Avery Company	869
Resistance Welder Mfrs. Association	881
Sciaky Bros.	859
Shawinigan Products Corp.	842
The Sight Feed Generator Company	850
A. O. Smith Corp.	861
Square D Company	835
Una Welding, Inc.	853
Union Carbide and Carbon Corp.	767
United Electronics Co.	879
United States Steel	855
United Welding Co.	842
Victor Equipment Co.	768
Westinghouse	Inside back cover and 844 & 845
Wilson Welder & Metals Co., Inc.	865

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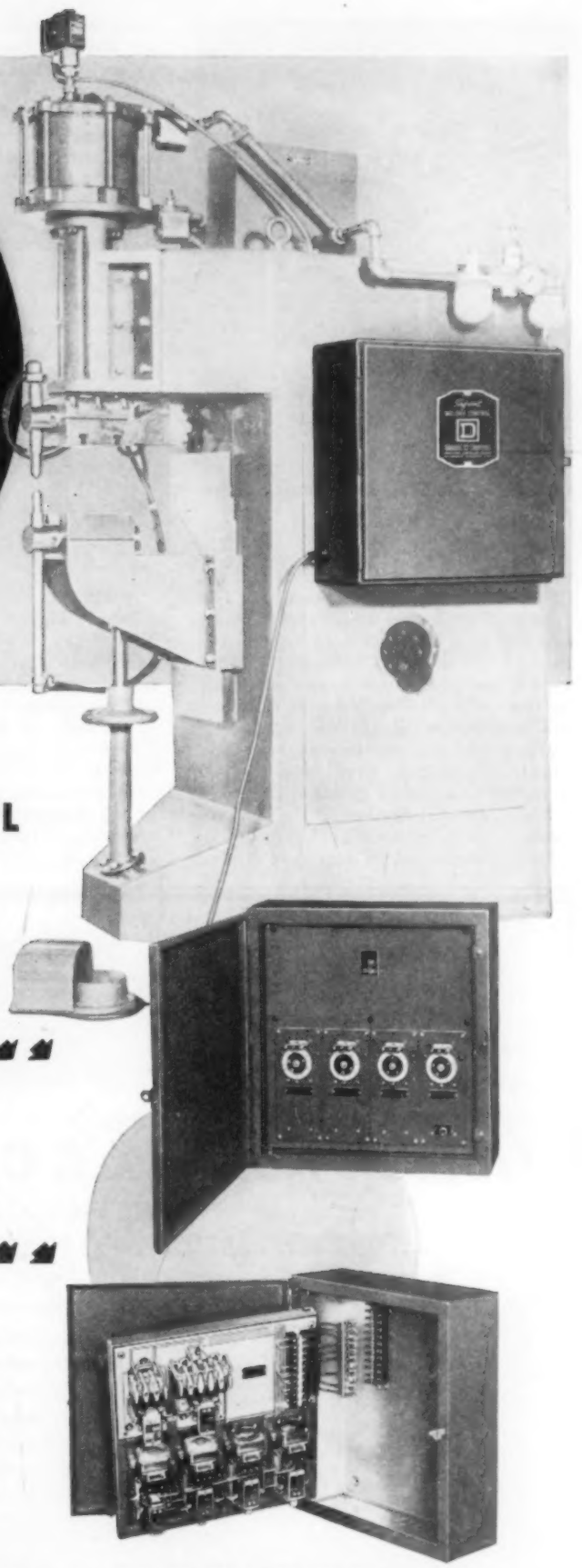

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Eric R. Seabloom

the Lane Technical High School and the Illinois Institute of Technology. In Dec. 1917 he entered the employ of Crane Co., Chicago, Ill., as a draftsman in the Product Engineering Department, later serving as an estimator and designer. In 1921 he was transferred to the company's Research Laboratories as a testing engineer and did development work on industrial products. From 1925 to 1935 he served as Research Engineer in charge of the Industrial Section of the Laboratories.

During this period his interest in welding grew and in 1932 he was given the position of Welding Engineer in addition to his other duties. The rapid growth of welding necessitated relinquishing his many assignments to devote full time to welding and welding research. In 1939 he was appointed Supervising Engineer of the Research Laboratories, a position he still holds, to coordinate the activities of the many laboratory groups. Welding still continues as his major interest.

Mr. Seabloom has contributed numerous papers, principally on welding, and has presented many talks before local sections of the SOCIETY. He served the Chicago Section as Vice-Chairman from 1941 to 1942, Chairman from 1942 to 1943 and was elected to the Chicago Section Board of Directors in 1943 for three years. He is also a member of the Welding Research Council.

* * *

J. H. Deppeler

J. H. Deppeler is Chief Engineer of the Metal & Thermit Corp. with office at 120 Broadway, New York, N. Y. He has been with this corporation since 1912 having graduated from Stevens Institute of Technology in 1906. From 1912 until about 1935, he was superintendent of its Thermit and Electrode plants and now is Chief Engineer of the corporation.

Mr. Deppeler was one of the founders of the AMERICAN WELDING SOCIETY and active in its affairs since the beginning. He has served on the Board of Directors

J. H. Deppeler

and Executive Committee. He has delivered literally dozens of addresses before Local Sections and at national meetings. He has enriched the literature with his comprehensive papers on Thermit Welding. He is considered an outstanding authority in the welding field. During recent years he has served the SOCIETY as Chairman of its Filler Metal Specifications Committee. He has been an in-

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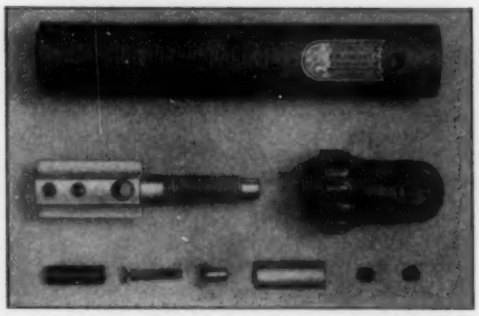

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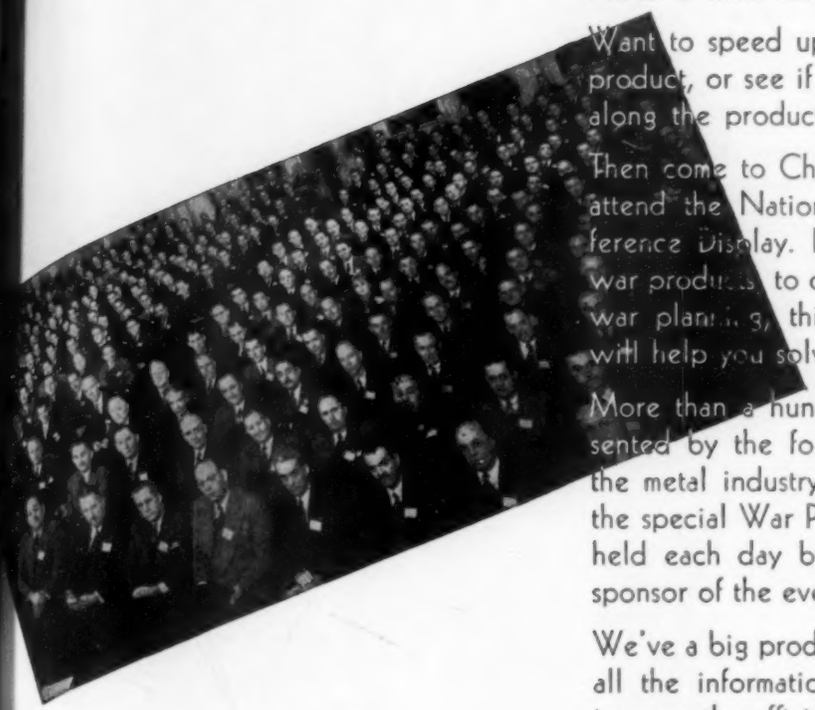

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Under the direction of the American Society for Metals, in cooperation with the American Welding Society, the Wire Association, and the Institute of Metals and Iron and Steel divisions of the American Institute of Mining and Metallurgical Engineers.

portant contributor to the two editions of the *Welding Handbook*. He was the Second President of the SOCIETY, 1920–21.

OUR DISTRICT VICE-PRESIDENTS

Middle Eastern—Charles H. Jennings

Charles Henry Jennings, one of the outstanding authorities on electric arc welding, was born in Des Moines, Iowa, Jan. 23, 1906. After being graduated from the Henry Sabin School and North Des Moines High School, he attended Iowa State College at Ames, where he received the Degree of Bachelor of Science in Mechanical Engineering in 1928.

Charles H. Jennings

Mr. Jennings was employed in the Des Moines Works of the Pittsburgh-Des Moines Steel Co. while still in college, and, with this practical experience as a background, was admitted to the Graduate Student Course of the Westinghouse Elec. & Mfg. Co. in 1928, completing the normal year's course in seven months.

In 1929 he became attached to the mechanics division of the Westinghouse Research Laboratories in East Pittsburgh, where he instituted advanced studies in the mechanical properties of welds, welding design, welding applications and welding problems.

In 1936 he was transferred to the Laboratories' chemical and metallurgical division and put in charge of all the welding research. In 1943 he was made Section Engineer of the Welding Sections. Mr. Jennings conducted a course in welding metallurgy at the Carnegie Institute of Technology, prepared a training course for welding operators for the Pittsburgh Board of Education and is the author of numerous articles on welding and two books—*How to Weld 29 Metals* and *41 Lessons in Arc Welding*.

In 1937 Mr. Jennings was called to England for three months as consultant welding engineer for the English Electric Co.

In 1939 Mr. Jennings was awarded the Westinghouse Silver "W" and Order of Merit for distinguished service in welding research and application. He is a member of the AMERICAN WELDING SOCIETY. He is married and has two sons.

Charles has delivered many addresses before the SOCIETY and its Local Sections. He is author of some of the leading papers on research published by the SOCIETY. He is Chairman of the SOCIETY's Committee on Standard Procedures for Welding and the Welding Research Council's Committee on Weldability of Carbon Manganese Steels. He is an important contributor to the Welding Handbook.

* * *

New York and New England—F. C. Fyke

F. C. Fyke, Head, Materials Division, General Engineering Department, Standard Oil Development Co., Elizabeth, N. J., is a graduate of Ohio Northern University with the degree of B.S. in Mechanical Engineering, 1916 (in 1921 he was awarded the degree of M.E. by the University). After two years of educational work in Minnesota he became associated with the Standard Oil Co., N. J., in 1918 as Test Engineer in the General Engineering Department. When this Department became a part of the Standard Oil Development Company in 1928 Mr. Fyke continued in this work. Since 1931 he has been head of the Materials Division which involves testing and inspection of materials and engineering research.

Being a member of the AMERICAN

F. C. Fyke

WELDING SOCIETY for many years he h served on a number of its committe He was one of the founders of the North New Jersey Section and served two ye as its Chairman and is now a member its Executive Committee. He is member of the Sectional Advisory Co mittee. He is a member of seve committees of A.S.T.M., A.P.I. and oth technical organizations.

* * *

Middle Western—G. N. Sieger

G. N. Sieger is President and Gener Manager of S-M-S Corp., Detroit. He a graduate of Mercersburg Academy Lehigh University, with the degree Electro-Metallurgist. In service ove seas with the A.E.F. he was in charge the production and distribution of no toxic gases; he received citation for activ ity in France. He was associated wit P. R. Mallory & Co., Inc. for twenty yea in executive and metallurgical capacitie as a matter of fact, helped in the formati of that company. Mr. Sieger has bee chairman of the WPB Industry Advisor Committee Task Committee on Resistan Welding Electrodes and a member of th Resistance Welding Machines Task Com mittee. He is also Metallurgical Consul ant to the Cutting Tools Section of WP

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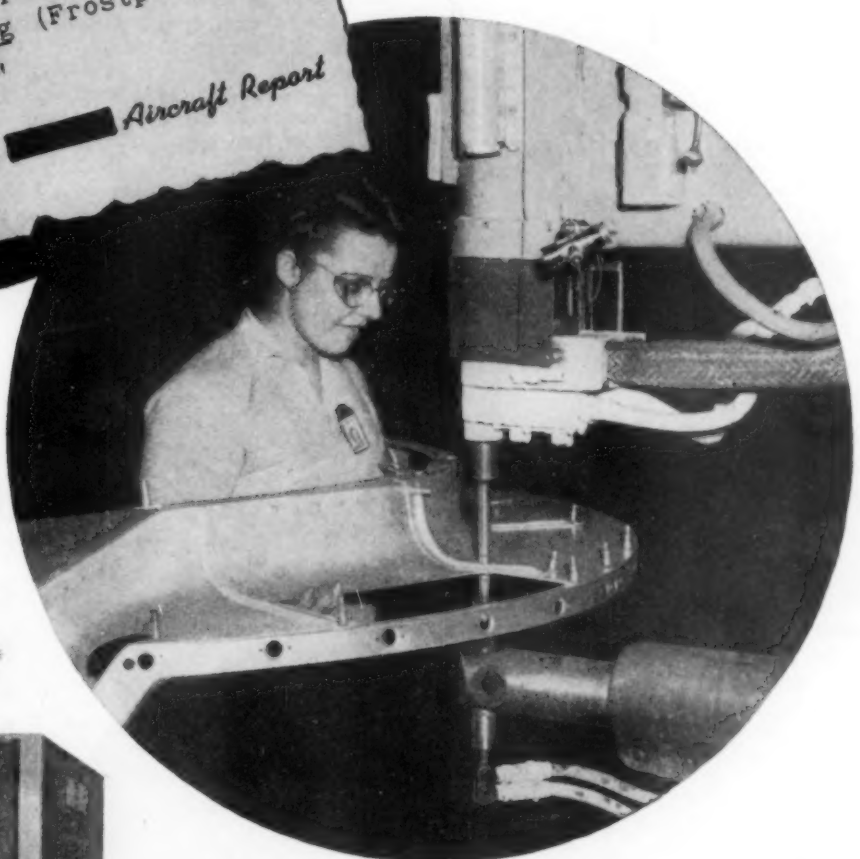

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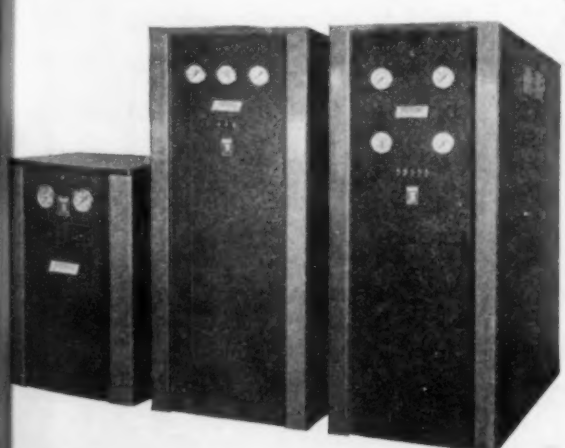

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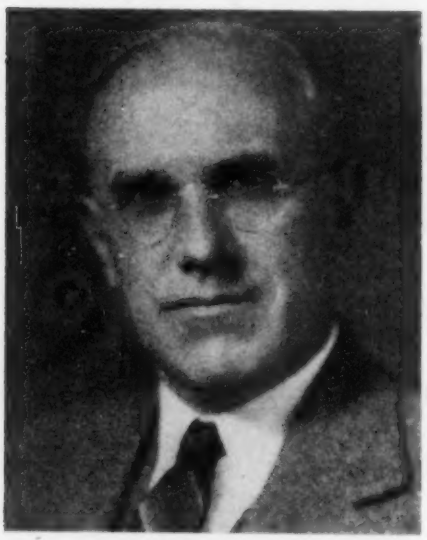
Mr. Sieger is a Past-Chairman and present Secretary of the Detroit Section,



G. M. Sieger

A.W.S. and present Chairman of the Membership Committee, A.W.S.

* * *

Southern—E. C. Chapman

Mr. Chapman attended Georgia Tech and Cornell University, graduating from the latter in 1928 with an M.E. degree.

He has been continuously with the Hedges-Walsh-Weidner Division of Combustion Engineering Co., Inc., since graduation. Since 1930, he has been connected with welding development and research, and his position now is metallurgist in charge of welding research.

E. C. Chapman

He is a member of the following Societies: AMERICAN WELDING SOCIETY, American Society for Metals, American Institute of Mining and Metallurgical Engineers.

He is also a member of several A.S.M.E. Boiler Code and A.S.T.M. subcommittees and also several A.W.S. committees. Mr. Chapman has been an important contributor to THE WELDING JOURNAL and to the *Welding Handbook*.

Pacific Coast—J. C. Gowing

"Jim" Gowing was born in Go... Ind., June 9, 1894. For the past ... years he has been the Southern Califor... District representative of Hobart B... Co. His general good humor, tire... energy and friendliness have won h... hundreds of friends. He has been act... in the SOCIETY'S affairs on the coast h... ing served as Secretary of the Los Ang... Section from 1939 to 1940, Vice-Cha... ma, 1940 to 1941 and Chairman, 19... to 1942.

J. C. Gowing

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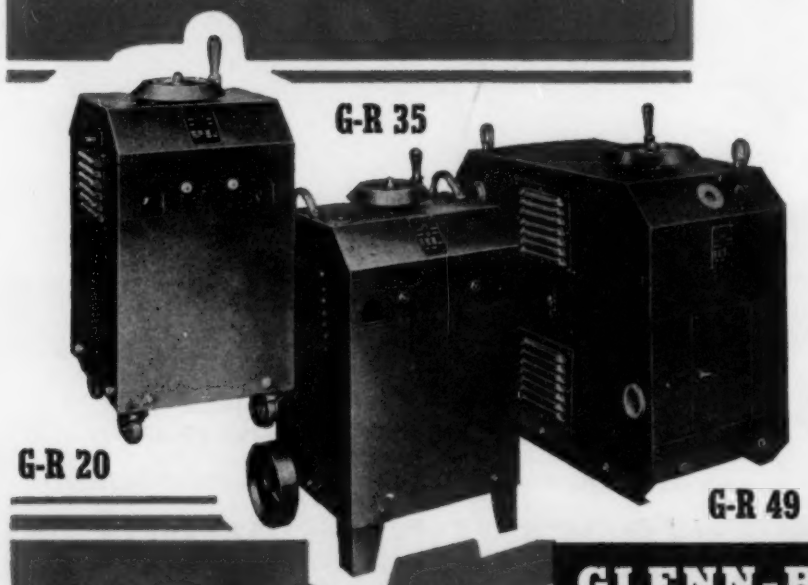

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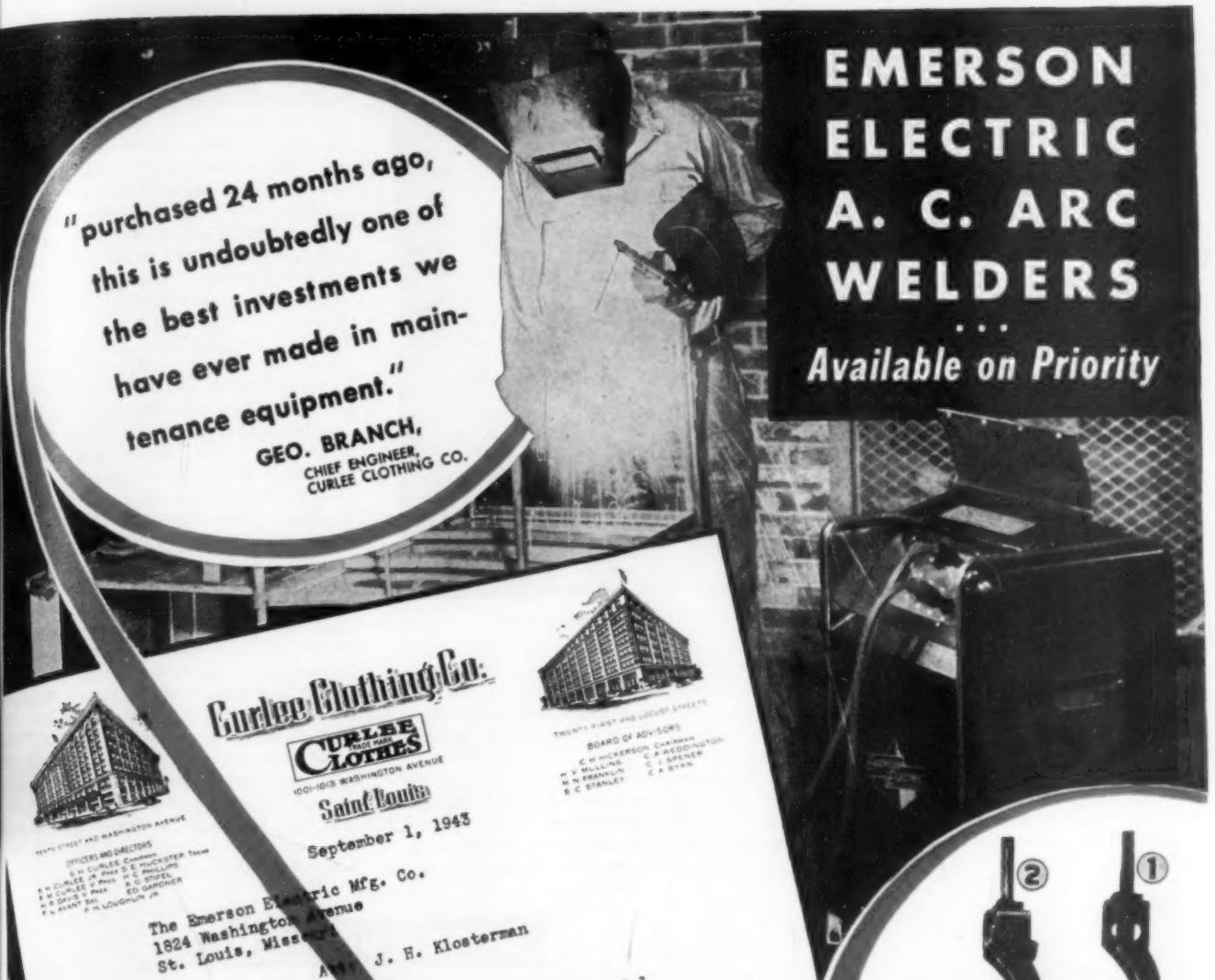

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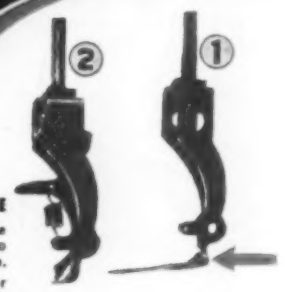
Geo. Branch

G. Branch, Chief Engineer



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THE ADAMS LECTURE

In order to honor the Founder and First President of the AMERICAN WELDING SOCIETY a lectureship has been created by the SOCIETY to be known as The Adams Lecture. The award will be made annually by the Board of Directors to an outstanding Scientist or Engineer who can prepare a suitable paper involving some new and outstanding development in the welding field. Dr. C. A. Adams has been selected to give the 1943 Adams Lecture.

C. A. Adams

Dr. Comfort Avery Adams, first Adams Lecturer, was born in Cleveland, Nov. 1, 1868. He received degree of B.S. in 1890, degree of B.E. in 1905 and the honorary degree of Doctor of Engineering in 1925 from Case School of Applied Science. He married Elizabeth C. Parsons, June 21, 1894 at Greenfield, Mass. He has two sons, John and Clayton C.

Dr. Adams started his professional career with the Brown Hoisting and Conveying Machine Co., but soon joined the Brush Electric Co. as Designing Engineer. In 1891 he became Instructor of Electrical Engineering at Harvard University. In 1896 he was elevated to position of Assistant Professor, and in 1906 he became Professor, and from 1911 to the time of his retirement from Harvard he was Lawrence Professor of Engineering. He was appointed Dean of Harvard Engineering School in 1919, but resigned shortly thereafter to accept the position as Chairman

Comfort Avery Adams

of the Engineering Division of the National Research Council. He returned to Harvard in 1921 and was made Professor Emeritus in 1936.

Dr. Adams is the author of many papers on electrical machine design and welding. As a striking illustration of the lasting quality of his contributions to the technical literature may be mentioned the series of papers on the leakage reactance of induction motors which he published almost forty years ago. The formulas developed in those papers have stood the test of time; they are still extensively used by designers of induction motors and referred to in modern textbooks on the subject. Dr. Adams has acted as a consulting engineer for the Okonite Co. from 1909 to date, for the Okonite Callendar Cable Co. from 1925 to date, for the Babcock & Wilcox Co. since 1926, the General Electric Company from 1927 to 1933, American Tool & Machine Co. from 1905 to 1930, for the Warner Sugar Refining Co. from 1910 to 1920. In 1932 he became consulting engineer for the Edward G. Budd Manufacturing Co., which position he still holds.

During the last war Dr. Adams was appointed by President Wilson a member and later Chairman of the General Engineering Committee of the Council of National Defense. He is also a member of the National Academy of Sciences.

Dr. Adams is a member of many societies including the American Academy of Arts and Sciences, the American Physical Society, the American Association for the Advancement of Science, the American Institute of Electrical Engineers, of which he was President from 1918 to 1919. He is also a member of the Institute of Electrical Engineers, London, the Verein Deutscher Engineer of Berlin, the Society for the Promotion of Engineering Education, the American Society of Mechanical Engineers, American Society of Civil Engineers, American Society for Testing

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Materials. He is a member of Sigma Xi, Tau Beta Pi, Pi Gamma Mu. Among the clubs of which Dr. Adams is a member are the Engineers of New York, Engineers of Boston, Engineers of Philadelphia, the Harvard Union, Harvard Faculty, Oakley Country Club (Watertown), Whitemarsh Valley Country Club (Philadelphia).

In order to speed up shipbuilding production in 1918, there was created a Welding Committee of the Emergency Fleet Corporation under the chairmanship of Dr. C. A. Adams. From this time welding began to receive serious consideration as a fabricating tool of industry, whereas, previously it had been accepted only as a repair tool, principally by the railroads. The work done by the Welding Committee laid the foundation for the organization, after World War I, of the AMERICAN WELDING SOCIETY and of its affiliated research organization known as the American Bureau of Welding. Dr. Adams was the first President of the AMERICAN WELDING SOCIETY and the first Director of the American Bureau of Welding, which position he held until the Bureau was discharged and a Welding Research Committee organized under the Engineering Foundation in 1936. Dr. Adams was made Chairman of this Research Committee which position he still holds. In other words, throughout the entire life of the AMERICAN WELDING SOCIETY, its guiding spirit in so far as its research work has been concerned has been Dr. Comfort Avery Adams, founder of the SOCIETY.

Although many types of research have been carried out by the American Bureau of Welding and by the Welding Research Council, the investigations that most fascinated Dr. Adams were those related to fundamentals aimed at the reason why of things. In connection with such investigations Dr. Adams has given unstintingly of his time. He has been most helpful in the development of programs and most zealous in making sure that the investigations were planned to establish fundamental principles. On the other hand, he has been aware that practical researches of the testing variety are often needed in the establishment of unit design stress or some other features of codes, standards and specifications, but such investigations have never been so dear to his heart as those dealing with the development of basic data needed for full understanding of the underlying phenomena involved.

Dr. Adams is a born leader. In addition to his engineering attainments he is a profound student of sociology, economics and general educational problems. He has thoroughly investigated the merits of taxation of the unearned increment in land values as a step toward equitable distribution of wealth in a free enterprise system.

To appreciate Dr. Adams' amazingly keen insight into social problems, one has only to read his presidential address to the American Institute of Electrical Engineers, delivered at the Institute's 1919 Summer Convention. The address, entitled "Cooperation," promulgates principles which are as applicable to the serious problems confronting the world today as they were when presented twenty-four years ago.

In so far as his means would allow, Dr. Adams has been a generous contributor to educational causes and the education of special individuals who came under his observation. He possesses a power of concentration that would be difficult to surpass. Perhaps the greatest outstanding ability of Dr. Comfort Avery Adams is his inspiration to others and his ability as a teacher. His professional teaching experience at Harvard covered a period of forty-five years. He is now and always will be a teacher. It is a source of pleasure to him to train young men to think for themselves, to understand what they are doing, to inspire them to reach for new knowledge.

Dr. Adams has won many important distinctions. His most recent one is the 1940 Lamme Medal for his work in electrical machine design. He was the first recipient of the Samuel Wylie Miller Medal. He is a member of the National Academy of Sciences and an Honorary Member of the AMERICAN WELDING SOCIETY.

The AMERICAN WELDING SOCIETY and the welding industry are indeed fortunate that Dr. Adams became interested in the development of welding and its placement on a sound, scientific basis some twenty-five years or more ago. Throughout these years he has managed to instill some of his high ideals in industry, the SOCIETY and to members of its staff. It is entirely fitting that the SOCIETY should create the Adams Lecture in honor of its first President and to name Dr. Comfort Avery Adams as its first Lecturer.

Surrounding him are his hosts of friends. Sharing in his honor and achievement are literally hundreds of people. These men have made their own mark in the engineering world and share with Dr. Adams the notable achievements that have made welding the greatest industrial production tool of modern times.

OBITUARY

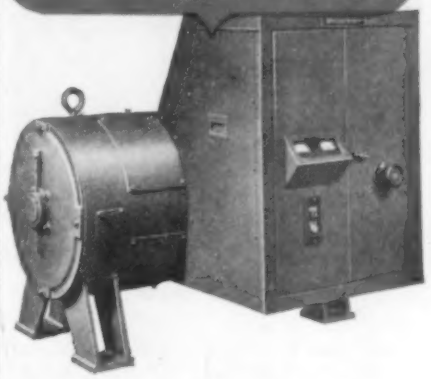
Leon S. Moisseiff

Leon S. Moisseiff, consulting engineer and one of the world's leading authorities on bridge construction, died September 3rd of a heart attack at his summer home in Belmar, N. J., at the age of 70. His New York home was at 530 West End Ave.

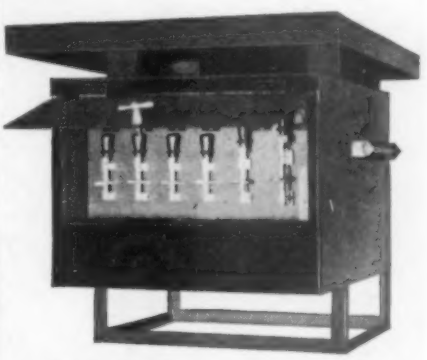
Mr. Moisseiff served as consulting engineer for the George Washington Bridge, the Bayonne Bridge, the Triborough Bridge, the Bronx-Whitestone Bridge and the East River bridges, all in the New York area, and for the Ambassador Bridge, Detroit; the Maumee River Bridge, Toledo, and the Tacoma Narrows Bridge, Tacoma, Wash.

The engineer of design of the Delaware River Bridge, Philadelphia, he also was a member of the board of engineers of the Golden Gate Bridge, San Francisco, and the San Francisco-Oakland Bay Bridge.

ONE
MULTIPLE-OPERATOR SET
DOES THE WORK OF
20 TO 30
SINGLE-OPERATOR SETS



For continuous-duty, mass production welding where a large number of operators can work in a small area, specify Westinghouse Constant-Potential Multiple-Operator Sets. Welding control panels can be assembled in banks or used singly. Operating power factor, where synchronous motor drives are used, will average 80% leading. Over-all efficiency is 45%.



Operator control panels are available in single and two-operator types. Current range is 150, 200, 250 and 300 amperes. Same range for each operator on two-operator types. Dripproof enclosures. For latest literature, write to Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa., Dept. 7-N. J-90477

Westinghouse
WELDERS
PLANTS IN 25 CITIES . . . OFFICES EVERYWHERE

Leon S. Moisseiff

Recipient in 1939 of the Egleston Medal of Columbia University for distinguished achievement in engineering, Mr. Moisseiff also received the gold medal of the Franklin Institute, the Norman Medal and the James Laurie Prize of the American Society of Civil Engineers, and the Modern Pioneer Award for achievement in the field of science and invention from the National Association of Manufacturers.

Born in Riga, Latvia, he was a student at the Emperor Alexander Gymnasium there from 1880 to 1887 and at the Baltic Polytechnic Institute in Riga from 1889 to 1891. He received his civil engineering degree from Columbia University in 1895.

Mr. Moisseiff came to this country in 1891, became a naturalized citizen in 1896. He was employed as a civil engineer with a private firm from 1895 to 1897. From 1897 to 1915 he was assistant engineer and engineer of design of the New York City Department of Bridges.

He went to Russia in 1929 and served for three years as consulting engineer of the Commissariat of Transportation. In 1940 he was named chairman of a structural steel welding research committee organized by the Engineering Foundation.

Mr. Moisseiff was credited with having developed the now universally accepted deflection theory of suspension bridges, a theory he first put into practice in his work on the East River bridges. The strengthening of the Williamsburg Bridge, involving two additional river piers, resulted from his designs.

He developed plans for rebuilding the Brooklyn Bridge and enlarging its capacity without interrupting traffic, and also was in charge for a considerable period of the Queensboro Bridge plans. He was one of the consultants for the suspension bridge at Cologne, Germany.

A voluminous contributor to the technical press on bridge problems, the first book in English on reinforced concrete was his compilation of Considere's Researches. He had been a member of the Advisory Board of Engineers for the War Department on structural steel and a member of the advisory committee to the United States Bureau of Standards on steel and fabricated metals.

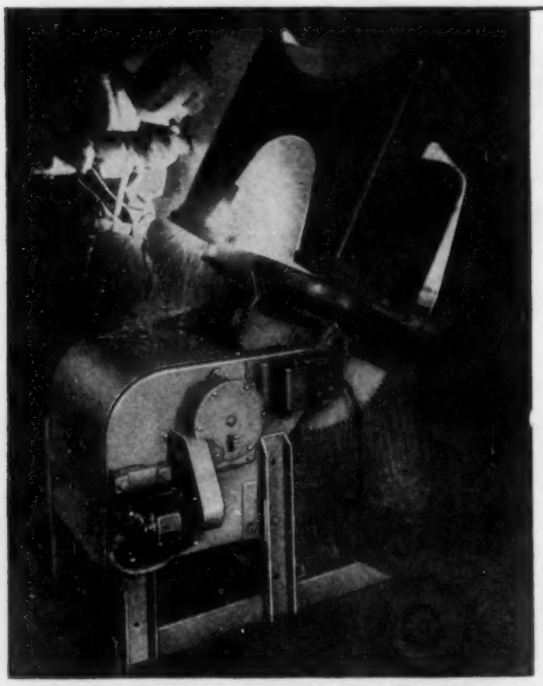
He leaves a widow, Mrs. Ida Moisseiff, a son, Siegfried Moisseiff, and two daughters, Mrs. Liberty Weiss and Mrs. Grace Smith.

Mr. Moisseiff was particularly active in the work of the AMERICAN WELDING SOCIETY. In addition to his serving as Chairman of the Structural Steel Welding Research Committee mentioned above, he was also Chairman of the Permanent Fund Committee of the SOCIETY. He was an important member of the A.W.S. Bridge Committee. He served as a Vice-President of the SOCIETY as a Director and also as Treasurer of the SOCIETY for a one-year period. In his death the AMERICAN WELDING SOCIETY lost one of its important friends.

Charles F. Williams

It is with deep regret that we announce the death of Charles F. Williams, a pioneer of the welding industry, who died at Chicago, Ill., on July 25th, at the age of 82.

Charlie, as he was known to all of us, had a record of over 31 years of active service in our industry. He entered the employ of Davis-Bournonville Co. on March 1, 1909, and became associated with the Air Reduction Sales Co. on March 17, 1922, the date of the acquisition of the



Low-cost 500-lb. capacity unit, available either hand-operated or motor-operated

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Most important, it will greatly increase your welding production. In many cases, it means that you can do a job in one pass that would require two, three, or more passes when the weldment cannot be placed in the ideal downhand position.

It means smoother, stronger, welds . . . time saved in both handling and welding . . . rod savings . . . and the good will of your welders.

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Install Ransome Welding Positioners. With this equipment, your welders can shift their work at will, without crane service, without loss of time, without wasting precious physical energy. Every seam is just where it should be . . . in position for downhand welding.

There's a unit to fit every welding job. ***Write for full information.***

Units on display at National Wartime Metal Congress... October 18 to 22 . . . Room 876, Palmer House, Chicago

Industrial Division · RANSOME MACHINERY COMPANY · Dunellen, New Jersey

Subsidiary of WORTHINGTON PUMP AND MACHINERY CORPORATION

Ransome WELDING POSITIONERS

P&H

AMERICA'S ONLY MANUFACTURER PROVIDING A COMPLETE WELDING SERVICE

Here, under one roof, the builder of welding equipment is also one of the world's largest users. Pioneers in production welding, P&H has always led the way with new methods and techniques as well as in designing for the welded fabrication.

The new P&H Production Welding Control System will be demonstrated at the Metal Show, Room 813, Palmer House, Chicago, Oct. 18-22, 1943.

PRODUCTION CONTROL SYSTEMS

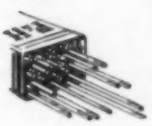
The P&H system of Production Welding Control can readily be applied to any of the basic methods of compensation to gain accurate control of (1) costs, (2) procedures, (3) production and (4) quality. Originated by P&H and used by other large companies, it is the practical solution to production welding control. Literature on request.

D.C. ARC WELDERS

All with single control and the new "Visi-matic" calibration plate. All P&H arc welders are rated on the WSR (Welding Service Range) basis, which tells you the exact amount of usable welding current, from minimum to maximum, for each machine. Capacities up to 600 amperes.

A.C. ARC WELDERS

A new series of industrial machines (for both intermittent and heavy duty service) with a wide range of capacities. All models provide the continuous, concentrated arc which is so easy to control. The complete line includes models from 20 to 1200-ampere capacity based on WSR ratings.



WELDING ELECTRODES

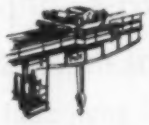
Produced under rigid quality control in one of America's most modern electrode plants. All sizes and types for maintenance and repair work such as for hard surfacing, resistance to impact, wear, and abrasion. Also for welding stainless, 4-6% chrome steels, armor plates, etc., as well as all types of mild steel electrodes.

WELDING POSITIONERS

A complete line of dual capacity welding positioners up to 24,000 lbs. capacity; power operated for handling various sizes and types of welded structures. New designs provide the utmost simplicity of operation to facilitate production welding. Literature on request.

ELECTRIC HOISTS

Used in welderies everywhere for the handling of steel, sub-assemblies, etc. All capacities up to 15 tons are made in three series of hoists which provide a variety of mountings to suit every need for lifting, lowering, or horizontal travel. Literature on request.



OVERHEAD CRANES

P&H is America's largest builder of overhead cranes. Whether for heavy duty or for intermittent service, P&H builds a size and type exactly suited for each requirement. You can count on P&H's honest delivery dates.

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HARNISCHFEGER CORPORATION
ARC WELDERS · EXCAVATORS · ELECTRIC CRANES P&H MOTORS · HOISTS · WELDING ELECTRODES

Davis-Bournonville Co. by Air Reduction.

He served, and served well, in the capacity of a service engineer until his retirement December 1, 1940. He was highly respected by his friends and associates throughout the organization and industry.

Albion James Wadhams

Albion James Wadhams of Dongan Hills, Staten Island, N. Y., a Vice-President and Manager of the Development and Research Division of The International Nickel Co., Inc., in New York, died at his summer home at Elizabethtown, N. Y., on Sunday evening, August 22nd, of a heart attack. He was 68 years old.

Born at Annapolis, Md., son of the late Rear Admiral (United States Navy) Albion V. and the late Caroline (Henderson) Wadhams, he was graduated from the United States Naval Academy in 1895. Mr. Wadhams served as an Ensign and later as a Lieutenant (j.g.) in the United States Navy from 1895 to 1901. He saw continuous sea service in North and South Atlantic and West Indies for 6 years, including the Spanish-American War during which he was attached to the U.S.S. *Mayflower*. During service in the United States Navy he received the Spanish War Medal and Sampson Medal.

He has been with The International Nickel Co. and its predecessor companies since 1901. Mr. Wadhams joined the Orford Copper Co. at Bayonne, N. J., on March 1st of that year. He was transferred from there in 1904 to the American Nickel Works at Camden, N. J., acting as Superintendent until 1912. From 1912–18 he was Assistant General Superintendent of Orford Works of International Nickel, becoming General Superintendent in 1918. Mr. Wadhams was named Manager of the Company's Development and Research Division in New York on April 1, 1922. In addition to this position, he has been a Vice-President of The International Nickel Co., Inc., since October 1935.

It was under his leadership and guidance that many of the wide applications of nickel and its alloys have been developed. He has written many papers on the history and uses of nickel.

Mr. Wadhams was a member of the American Iron and Steel Institute, American Institute of Mining and Metallurgical Engineers, American Society of Naval Engineers, American Society for Metals, Mining & Metallurgical Society of America, Navy League of the United States, New York Electrical Society, Princeton Engineering Association. Society of Naval Architects and Marine Engineers, The Newcomen Society of England, United States Naval Institute and American Association for Advancement of Science. His clubs were the Army and Navy Club, Washington, D. C.; Richmond County Country Club, Staten Island, N. Y., Cobble Hill Golf Club of Elizabethtown, N. Y., and Navy Athletic Association, Down Town Association and The Naval Academy Association of New York.

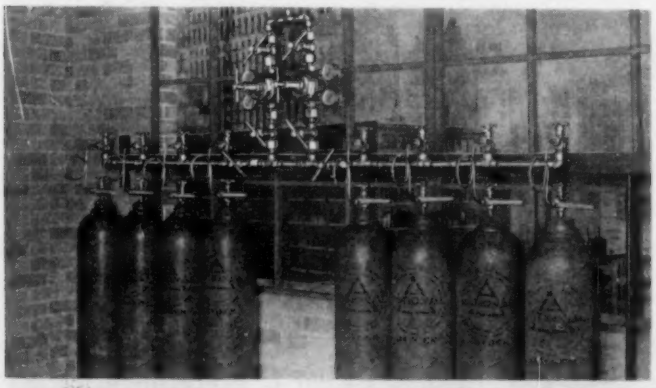
In 1902 Mr. Wadhams married Marcia Elizabeth Hand, of Elizabethtown, N. Y., who died on August 21, 1936. Surviving are two daughters and two sons, Mrs. Edward J. Carleton, of Woodstock, Conn., and Miss Elizabeth H. Wadhams of Dongan Hills, S. I.; Albion James Wadhams, Jr., Captain, U. S. Army and Richard H. Wadhams of Wilmington, Del., who is with the Du-Pont Company.

Mr. Wadhams was an ardent supporter of the work of the Welding Research Council since its inception.

"E" FLAG

"United Electronics Co. has made a vital contribution to the war effort in the saving of tons of critical materials." This was asserted on Thursday afternoon, August 12th, by Colonel C. O. Bickelhaupt, Commanding Officer, Eastern Signal Corps Replacement Training Center, Fort Monmouth, principal speaker at ceremonies attendant upon the award of the Army-Navy "E" flag for excellence of production to United Electronics Co., Newark, N. J., at the Essex House, Newark. Seven hundred and fifty people attended.

Colonel Bickelhaupt presented the "E" flag to R. H. Amberg, president of United. Mr. Amberg was described as "a tube engineer of distinction who has been in the transmitting tube field for approximately 30 years."



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Want to spot weld aluminum and aluminum alloys FASTER . . . also obtain STRONGER welds? Then try the NEW, effective, SAFE Oakite Process for getting surfaces thoroughly free from oil, grease, stamping compound, identification paint and oxide film.

You'll find it helps you STEP-UP OUTPUT . . . and get welds that are MORE UNIFORM, too! Special technical bulletin FREE to process engineers, welding foremen and other executives responsible for this work. Write for YOUR copy TODAY!

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How to control

CREVICE-CORROSION

Because welded seams and lap joints containing crevices may become sites for a special, rapid corrosive action when exposed to corrosive liquids, crevice-corrosion warrants the careful attention of welding engineers, especially in these days when metal conservation is so vital.

Crevice-corrosion, or concentration-cell corrosion as it is technically known, can become very serious since in addition to its speed, it usually occurs in hidden or secluded areas and thus escapes early detection.

Other conditions such as scale and similar deposits can also cause similar concentration-cell effects which all owe their rapid corrosive action to self-generated electric currents.

The general practices listed here for preventing concentration-cell corrosion include several suggestions for insuring crevice free joints, and the attention of welding engineers is called especially to the importance of securing complete penetration of weld metal at all times. INCO's Technical Service, on request, is prepared to assist welding engineers further in solving or avoiding concentration-cell corrosion problems.

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street, New York 5, N. Y.

CONTROLS

1. In new equipment specify butt joints and emphasize the necessity for complete penetration of the weld metal to guard against even minute crevices.

2. Lap joints either welded or rivetted should be avoided wherever possible or thoroughly sealed with weld metal or solder.

3. Existing lap or spot welded joints, that show evidence of crevice corrosion, should be cleaned as well as possible and all channels for liquid penetration—rivet heads, overlaps, and all crevice-like areas—sealed with weld metal, solder or caulked.

4. In design of vessels avoid sharp corners, stagnant areas or other sites favorable to the accumulations of precipitates and other solids.

5. Institute a routine of frequent, thorough cleaning of all metal areas subject to accumulations of deposits, scale or "skins."

6. In the design and operation of tubular heat exchangers endeavor to provide for uniform flow of liquid with a minimum of turbulence and air entrainment.

7. Provide suitable strainers in heat exchanger cooling medium lines to prevent local obstructions within the tubes which may start deposit attacks, or result in turbulence and impingement.

8. Remove all wet packing materials (unless of the corrosion-inhibiting type) from any equipment scheduled for a long shut-down period since concentration conditions under packings may become similar to those under deposits.

9. Because soaked timbers in contact with metal surfaces—tie-rods, pipes, stay-bolts, and similar members—promote concentration-cell effects, keep tie-rods tight and promptly repair all leaks in wooden tanks, even those that might otherwise be considered trifling. When soaking of timbers cannot be prevented, fastenings of highly corrosion resisting metals offer the best protection. Fastenings of less resistant metals may be somewhat protected by coating with a suitable paint before installation.

• • •

A detailed and simplified explanation of concentration cells, their action and control, is given in our bulletin "How to Recognize and Control Concentration-Cell Corrosion." A copy is yours for the asking, together with a copy of the Corrosion Data Work Sheet which you are invited to use in requesting corrosion resistance data for a specific corrosion problem.

In one particular type tube, it has been common practice by the manufacturer to use pure molybdenum sheet as the anode plate. Molybdenum is one of those "critical materials" and has sometimes been a bottleneck in tube manufacture. United Electronics Co. developed and put into use the zirconium treated graphite anode, and obtained Signal Corps type approval. On this one contract alone, it has been estimated that United Electronics will save over one ton of pure molybdenum rolled sheet.

In addition to the saving made on this one contract, United Electronics has made these graphite anodes available to other manufacturers.

NEW WELDING HOUSE ORGAN

"The New Welding Arcs" is published bi-monthly by General Electric to encourage the wide exchange of helpful "know-how" welding information. Gordon F. Price is the Editor, General Electric, Schenectady, N. Y.

Mr. Price states:

"Every time-saving or material-saving idea, every improvement in technique or welding procedure, is a fighting weapon that must be given the widest distribution possible.

"Ideas or 'tricks of the trade' that you have already put to work in your plant to save materials, improve quality, or to speed up production, may be just what another plant needs to break a bottleneck. In turn, his suggestions may help you do the same."

SAFETY CONGRESS

The National Safety Congress, in Chicago on October 5th, 6th and 7th, will mark one of the most important milestones in the entire history of the accident prevention movement.

Last year's Congress started the machinery of the nationwide drive to save manpower for warpower. With that campaign in high gear this year's program is devoted exclusively to accident problems which have a direct bearing on prosecution of the war and winning it.

The National Safety Congress, which is the annual convention of members of the Council and other safety leaders in the military, agricultural, industrial and civilian life of the country, actually is 26 conventions within a convention, and annually draws 10,000 safety leaders from all over the country. The 5700 corporate and other members of the Council are classified in 26 membership sections, according to type of industrial enterprise represented by each member.

Each of these 26 Sections conducts its own Congress program, thus bringing purposeful emphasis to the particular accident problems current in every kind of industry.

KEWANEE BOILERS WIN WHITE STAR ON "E" PRODUCTION FLAG

The White Star Award from Under Secretary of War Robert P. Patterson, was this month added to Kewanee Boiler Corp.'s "E" Pennant for continued production merit.

AERONCA AIRCRAFT CORPORATION WIN ARMY-NAVY "E"

Aeronca Aircraft Corporation was admitted this month into the distinguished group of those who have earned the coveted Army-Navy "E." The company is the first lightplane manufacturer to win the coveted symbol.

SECOND STAR IN "E" FLAG FOR P&H

Earning the right to continue flying the Army-Navy "E" production banner, Harnischfeger Corp. was awarded a second star for the emblem at a simple ceremony on August 17th. Presentation was made by Lt. Com. D. M. Curry of the local headquarters of Naval inspection, and Walter Harnischfeger, P&H president, thanked employees for doing their part.

Being one of the first in the Milwaukee area to win the Services' recognition for outstanding performance, Harnischfeger Corp. has steadily maintained its output

the THREE *Freedoms*

1 **Freedom from large-job interruptions . . . How? Sight Feed's *visible* carbide supply!**

2 **Freedom from acetylene delivery delays . . . How? Sight Feed makes you *independent* of "bottlers"!**

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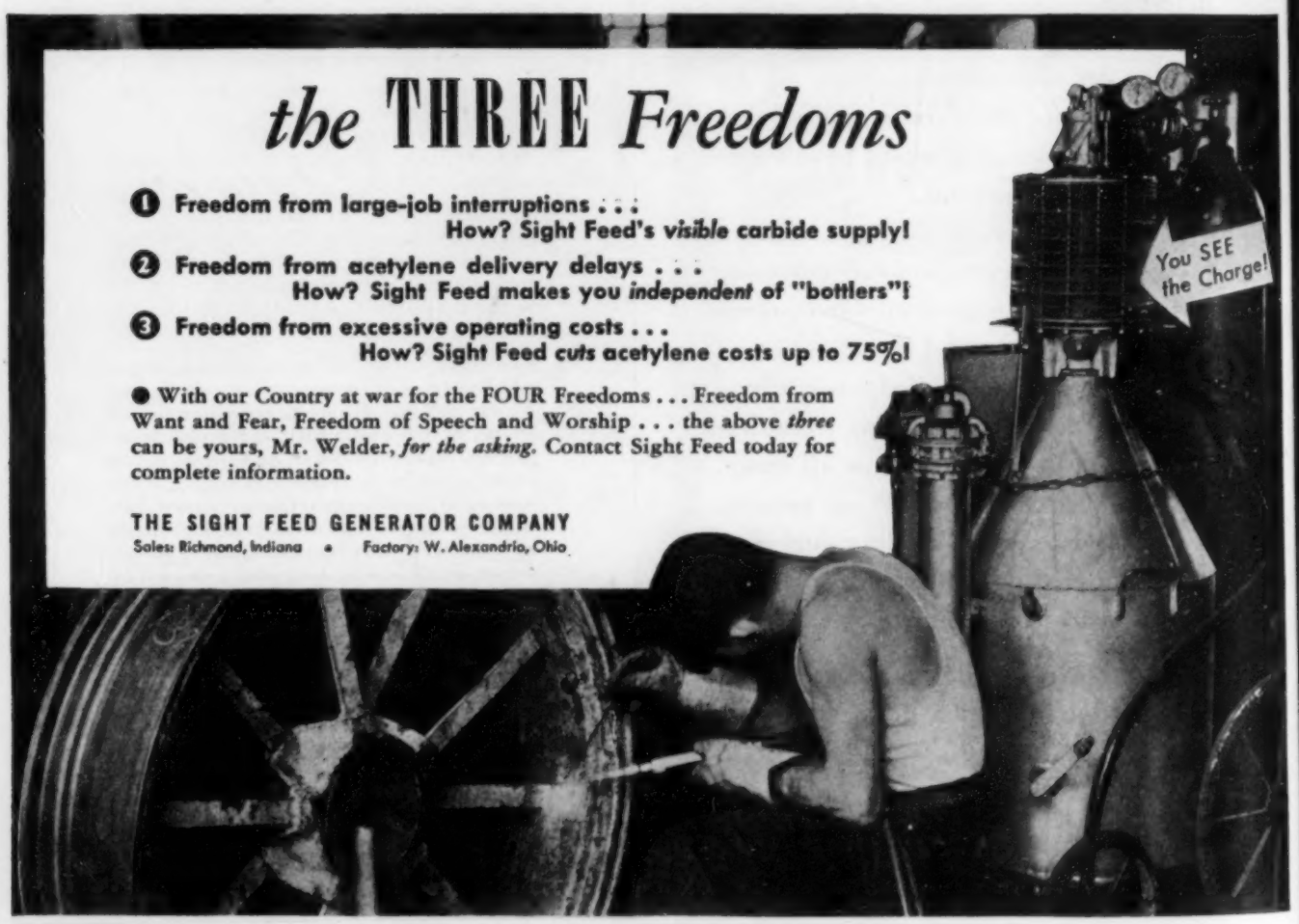
● With our Country at war for the FOUR Freedoms . . . Freedom from Want and Fear, Freedom of Speech and Worship . . . the above *three* can be yours, Mr. Welder, *for the asking.* Contact Sight Feed today for complete information.

THE SIGHT FEED GENERATOR COMPANY
Sales: Richmond, Indiana • Factory: W. Alexandria, Ohio



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...Get in touch with your AO Safety Representative *Today*

Good news for *all* Filterweld users! Present stocks indicate that there will be no waiting for Filterweld Welding Plates.

Filterweld, developed by American Optical Scientists in the same AO laboratories that produced Calobar, Noviweld and more recently, Noviweld-Didymium, is a completely service-proved welding glass for helmets and handshields. Equivalent to Noviweld in needed ultra-violet and infra-red absorption, all Filterweld Welding Plates are scientifically controlled in production . . . have fixed standards of densities . . . and conform with the U. S. Bureau of Standards specifications.

Order the Filterweld Plates you need from your AO Safety Representative today. Filterweld is available in Shade Numbers, 8, 9, 10, 11, 12, and 13.

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at high levels. The company's principal products are electric overhead traveling cranes with capacities up to 300 tons, electric hoists, a.-c. and d.-c. arc welders and welding electrodes, and a wide line of gasoline, Diesel and electric-powered crawler cranes and excavators up to 5 cu. yd. capacity. These products are universally known by their P&H trademark, and are serving all branches of the armed forces, as well as all vital war industries. Currently, a line of newly designed dual-capacity welding positioners is being introduced.

JONES APPOINTED SALES MANAGER

Cutler-Hammer, Inc., Milwaukee, Manufacturers of Motor Control Apparatus, have just announced the appointment of Mr. P. S. Jones as General Sales Manager for the Company. In his new duties Mr. Jones will have direct supervision of sales for the Company through its 30 selling territories throughout the country.

Mr. Jones first became associated with the Company at Milwaukee as a sales engineer in 1915, and he was transferred to the Pittsburgh office in 1919, where he was later appointed as Branch Manager of the Pittsburgh Sales Territory. For the past 14 years prior to his new appointment Mr. Jones was in charge of the New York sales territory.

Mr. Jones is a graduate of the Ohio

P. S. Jones

State University where he obtained his B.E.E. in 1915.

METAL & THERMIT APPOINTMENTS

Metal & Thermit Corp., 120 Broadway, New York, N. Y., announces the appointment of Mr. William C. Cuntz as District Manager, Welding Division, with headquarters at the Corporation's branch office, 1514 North Ave., West, Pittsburgh, Pa.

Mr. Cuntz joined the Metal & Thermit organization in 1936 and has been engaged in sales and service work in connection with Thermit welding and Murex electrodes since 1937. He attended the Colorado School of Mines at Denver and is a graduate Metallurgist of Lehigh University.

The territory under his supervision will include Southern New Jersey, Pennsylvania, Ohio and all of the Southeastern States including Kentucky, Tennessee and Alabama.

Louis G. Vock and James M. Wilson have been appointed District Engineers, Thermit Department.

Mr. Vock will operate from the Corporation's branch at 7300 So. Chicago Ave., Chicago, Ill., and Mr. Wilson from its branch at 1514 North Ave., West, Pittsburgh, Pa. Both men have served the Corporation for many years in the capacity of Service Engineers and are well known to the steel mills, shipyards and street railways in their respective territories.

A CORRECTION

In the February 1943 issue of THE WELDING JOURNAL an article appeared reviewing a series of 15 slidefilms for training welders. In the September 1943 issue, through an error, it was made to appear that these films may be obtained at 65 cents each from the distributor. The latter item refers to a single slidefilm, "Tips on Slidefilms," the sole purpose of which is to picture and explain the best methods of *using* slidefilms in training. The 15 welding slidefilms are priced at $41.50. Both the welding series and the single slidefilm are distributed by The Jam Handy Organization, 2000 E. Grand Blvd., Detroit, Mich.

Castolin Eutectic

EUTECTIC*
(Means Lowest Binding Alloy)
LOW TEMPERATURE WELDING

Air compressor with cracked water jacket. Salvaged with Eutectic Low Temperature Welding Alloy. No general preheating. Time: 1½ hours.

Tungsten tipped tool with new butt welded tip. Eliminates recessing shank. No sacrifice in strength or efficiency. Welded with high tensile Eutectic Alloy No. 16.

Aluminum screw machine part welded to light gauge aluminum sheet without damage to light sheet. Eutectic Low Temperature Alloy No. 190 . . . binds at 200° F. below melting point of parent metal.

EUTECTIC Low Temperature Welding Alloys are the original low temperature alloys that are revolutionizing production welding, maintenance welding and salvaging in war plants throughout the nation. There are 43 specialized rods for every metal and every welding job . . . the widest range in the U.S.A. Whatever your welding problem — present it to Eutectic first!

When You Buy Eutectic Alloys You Buy "Service"

Eutectic Alloys are being marketed under a new "formula" for user satisfaction: Eutectic Alloys are supplied directly to the user and every rod is backed by the manufacturer • Our laboratory and 60 field engineers are at your service. These men will cooperate with you to solve your welding problems and make proper recommendations to assure you of best results from Eutectic Alloys.

See Demonstration
National Metal Congress
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NEW 36 PAGE WELDING DATA BOOK E
Contains Vital Data on • Production • Maintenance • Salvaging • Write Today

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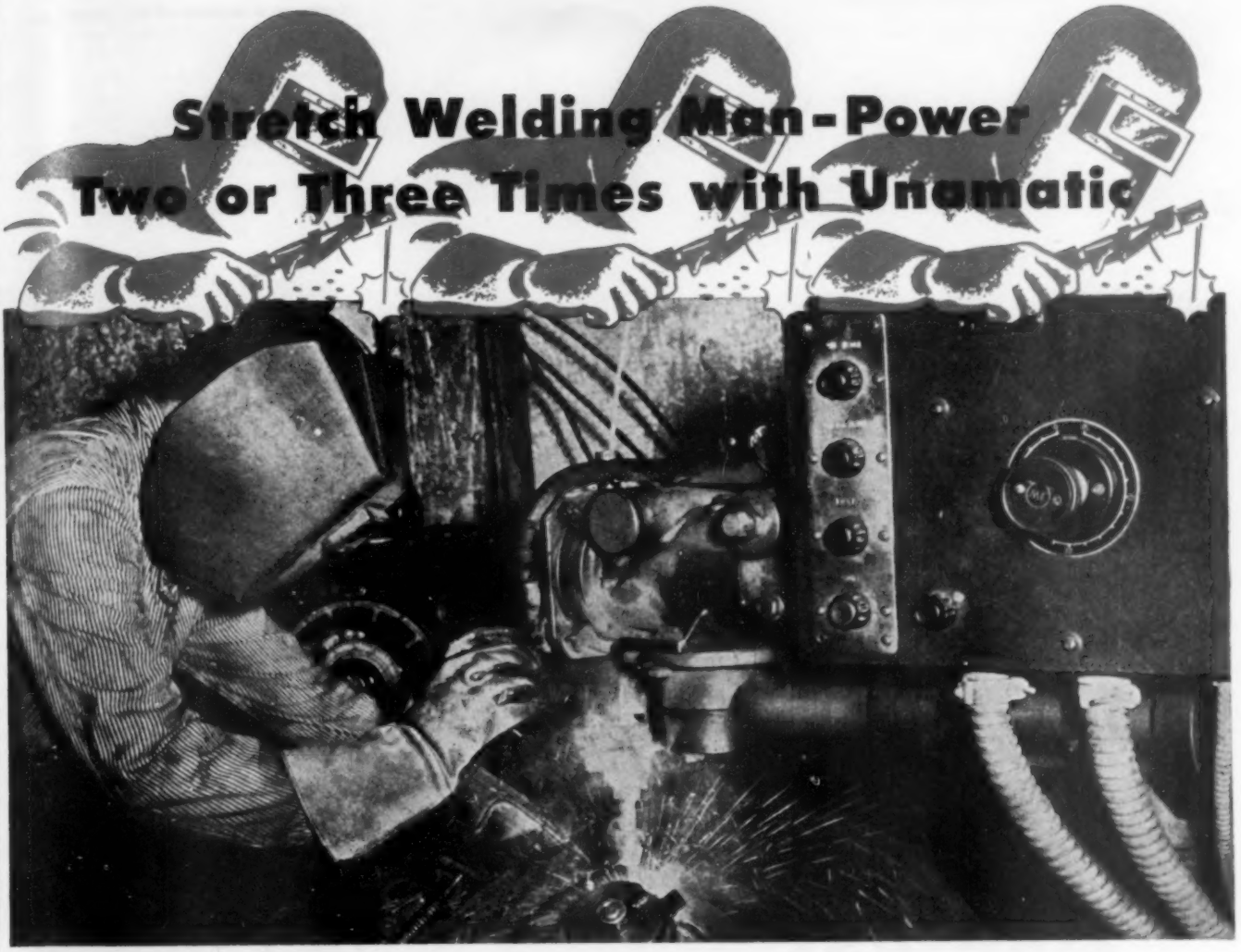
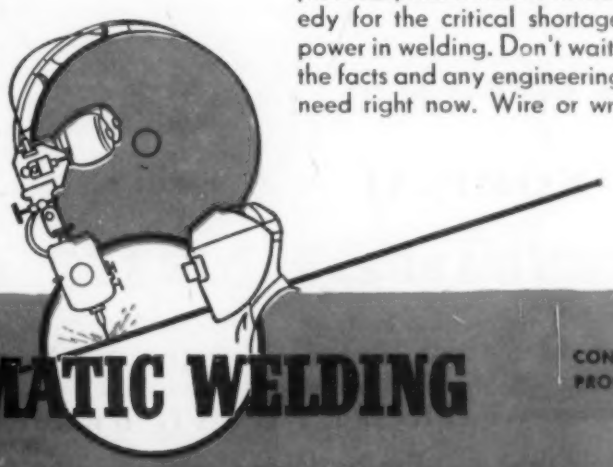
Stretch Welding Man-Power Two or Three Times with Unamatic



DOUBLE or triple your welding output even with your reduced available man-power, improve quality, lessen rejects and increase your war production now by installing Unamatic equipment immediately. With a nucleus of experienced manual welders as foremen-operators additional Unamatic equipment can, in many cases, be operated by men or women who are not of the highest skill. In the awarding of new contracts, companies which get out the most production per man hour will be given most consideration.

Unamatic welding is two, three or even four times as fast as manual operation on shielded arc work — and even faster using light coated wire. If you are welding now you are eligible with W.P.B. to buy new Unamatic equipment by switching your present welders to automatic production.

Wider use of Unamatic equipment is the most practical, immediate and obvious remedy for the critical shortage of man-power in welding. Don't wait — get all the facts and any engineering help you need right now. Wire or write today.



CONTROLLED QUALITY

UNAMATIC WELDING

CONTINUOUS PRODUCTION

UNA WELDING INC. • 1615 COLLAMER AVE. • CLEVELAND, OHIO

LINCOLN CONSULTING ENGINEER

The Lincoln Electric Company, Cleveland, Ohio, announces the appointment of William J. Conley, former chairman of the Engineering Department of the University of Rochester, as consulting engineer. He will act as a Lincoln welding consultant for various industries, handling problems on mechanical and structural design utilizing welding, as well as metallurgical problems involving welding processes.

In connection with his work, Mr. Conley will have charge of the company's welding educational activities, consisting of courses in welding engineering and design as well as lectures and talks on welding in the plant and in the field before technical societies and industrial groups.

Receiving his degree in Mechanical Engineering from the University of Rochester in 1918, Mr. Conley soon afterward was serving as a lieutenant in the U. S. Army Engineers. Following the war, he entered upon his industrial career with the Gleason Works in Rochester and after two years returned to the University of Rochester as an instructor in Applied Mechanics.

From 1920 to the present, Mr. Conley was advanced to assistant professor, junior professor and professor in charge of the Engineering Department and comes to Lincoln with broad experience and sound engineering knowledge.

During his university teaching, he was called in by many industrial plants in Rochester and western New York State as a consultant, and for some of the smaller companies handled the entire metallurgical development, including the processing of metals—such as machining, welding, forming cold, casting and heat treating.

William J. Conley

Mr. Conley's specialization in welding technique and his experience in processing and in new product development will be of great assistance to industry in efficient application of welding to design, manufacture and construction.

Conley is a member of the American Welding Society and American Society for Metals. He is also a member of the American Institute of Mining and Metallurgical Engineers, American Electroplaters Society, the Society for the Promotion of Engineering Education, Sigma Chi and Sigma Xi Fraternities. He is married and has one son in the Army Air Corps. A daughter enters the University of Rochester this year.

OFFICE OF WAR INFORMATION UNITED STATES MARITIME COMMISSION

Declaring that modern advancements in welding have made possible our present enormous output of ships, Rear Admiral Howard L. Vickery, Vice-Chairman of the Maritime Commission, today asserted that in every shipyard capable welding supervisors and operators can increase the quality of a ship and the speed with which it is built.

In a brief introduction to a new instruction booklet directed to all contractors constructing ships for the Maritime Commission, Admiral Vickery pointed out that inexperienced and poorly skilled welding supervisors and operators can and do upset production schedules.

Compiled by a representative group of men active in merchant and naval shipbuilding, the new booklet, entitled "Welding Instructions," will be sent out immediately to supervisors, leadermen

National

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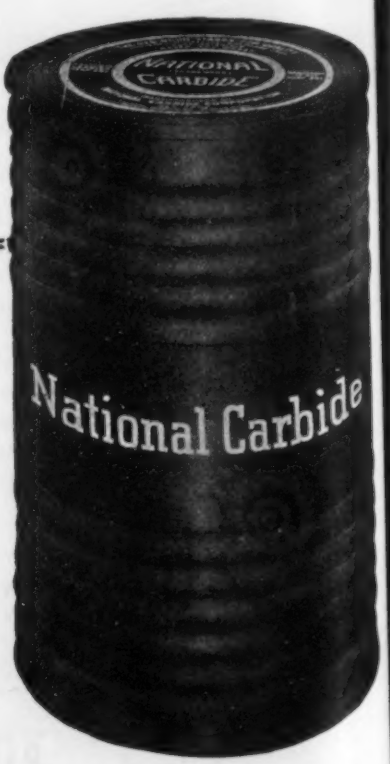
IN THE RED DRUM

EFFICIENT

ECONOMICAL

DEPENDABLE



FOR WELDING and CUTTING

Use National Carbide in the Red Drum

60 E. 42nd St. NATIONAL CARBIDE CORPORATION New York, N. Y.

When Welding Knowledge met a wartime emergency

U. S. Signal Corps Photo

U·S·S Rolled Steels for Welding include:

U·S·S High Tensile Steels to resist corrosion and increase strength without adding weight.

U·S·S Copper Steels to give twice the atmospheric corrosion resistance of regular steel at little additional cost.

U·S·S Abrasion-Resisting Steel to combat wear and friction.

U·S·S Stainless and Heat Resisting Steels to assure high resistance to corrosion and heat, and to reduce weight.

U·S·S Carilloy Alloy Steels— Special steels for the special jobs of industry.

U·S·S Hot-Rolled and Cold-Rolled Steels to provide the basic advantages of steel, plus maximum economy in accordance with the requirements of each job.

THE need for a new offensive weapon was crucial. Enemy tanks *had* to be knocked out! Then —advanced welding technique and special purpose steels helped put added mobile fire power in the field, quickly—in quantity.

The welders immediately went to work on chassis of medium tanks, already in production. They fabricated and installed heavy guns, turrets, the necessary reinforcements and additional protective armor of rugged, highly weldable rolled steel. That's how tank busters were born.

In other wartime emergencies, too, welders have been able to make full use of the findings of our welding engineers who, by exhaustive tests, have determined the type of U·S·S Rolled Steel and the specific welding method best fitted for each welding job.

As the world's largest producer of rolled steel, we maintain a technical staff for the sole purpose of determining the welding characteristics of each type of U·S·S Rolled Steel and the best welding method for each type of application.

Upon request our engineering consultants will be glad to assist you in solving your individual problem.

U·S·S ROLLED STEELS FOR WELDING

CARNEGIE-ILLINOIS STEEL CORPORATION, *Pittsburgh and Chicago*

COLUMBIA STEEL COMPANY, *San Francisco*

TENNESSEE COAL, IRON & RAILROAD COMPANY, *Birmingham*

United States Steel Supply Company, Chicago, *Warehouse Distributors*

United States Steel Export Company, New York

UNITED STATES STEEL

etc., of all crafts concerned with shipyard welding. It is also being furnished for their guidance to all Maritime inspectors.

The booklet sets forth a standard system of welding practice to be adopted by all branches of shipyard welding, with a view toward increased safety as well as quality and speed of training procedures.

"As our experience in the present shipbuilding program has increased," Admiral Vickery said, "it has become obvious that a comprehensive analysis should be made of common welding difficulties encountered in building ships and that an authoritative set of instructions as to what should be done and what should be avoided ought to be issued for the benefit of all shipyards and their production organizations."

For many months, the Admiral said, shipyard training and production departments have been searching for material that could be used with confidence in training the members of the welding, ship fitting and other concerned departments in the proper welding techniques to be used on a ship from keel laying through to delivery of the vessel.

The booklet places considerable emphasis on the necessity for welding supervisors to realize the importance of making sound welded joints. Flaws in a weld which may seem minor in themselves, it is pointed out, may well prove to be the starting point of a serious structural failure under service conditions.

In presenting the new booklet the Maritime Commission hopes to acquaint shipyard workers and their supervisors with easier, safer and more expedient welding methods, thus aiding both management and labor to continue with increased impetus the job of carrying out the greatest shipbuilding program in world history.

STORED ENERGY WELDERS

A comprehensive pamphlet of 16 pages describing the electromagnetic stored energy system for the spot welding of aluminum and its alloys has been issued by the Sciaky Bros., 4915 West 67th St., Chicago 38, Ill. The pamphlet covers a description of the system and its advantages. Several pages are devoted to the Sciaky Variable Pressure Cycle of the Electrode Tips, the Electrical Features and Examples of Production. Another section includes Mechanical Features and Engineering Data on the Welding of Aluminum, Magnesium and Stainless Steel.

USING TODAY'S SOLDERS

Today's solder decidedly differs from prewar solder, and so should soldering technique. Previously solder was composed of tin and lead in about 50–50 ratio; today, except for certain applications, solder contains not more than 20% tin, with perhaps small amounts of silver, bismuth, antimony or tin. Today's soldering technique calls for a hotter soldering iron, and attention to certain details. How to make better soldered joints has been explained in a communication issued by the metallurgy committee of the General Electric Company, which says:

1. Keep your work clean. Guard carefully against varnish, grease, oil, dirt, rust or corrosion products. They prevent the flux from acting and the solder from alloying with the parent metal.
2. Keep in mind that the purpose of the soldering iron or torch is not to melt the solder but to heat the work until the solder will flow when applied to the work.
3. Keep the soldering iron clean and, to have the quickest possible heat transfer from the iron to the work, have the tip designed actually to fit against the work.
4. Investigate different methods available for doing the work—hotter electric iron, high frequency or carbon resistance soldering tools may do the job better.
5. Design your joints to have 0.003 to 0.005 in. solder thickness, and so that the two parts overlap. Lap or seam-type joints are better than butt-type joints. Have the solder fill the seam completely. Heavy fillets add little strength to the joint and waste solder.
6. Don't hand a new solder, a flux and a soldering job to a workman and expect a perfect job the first time. Let him get the "feel" of the new material. Don't give up a new solder after one unsuccessful trial—the chances are your technique is not what it should be for that particular solder.

GREENPORT WAR VESSELS

Since the days of the whaling ships Greenport, Long Island, has upheld a tradition for fine shipbuilding, but prior to World War 2 all of their construction work was of wooden ships such as the Naval Minesweepers, which the company is now building. However, when the United States entered the present war, our Navy had vital need of many types of steel craft, and in February 1942, The Greenport Basin and Construction Co. received a government contract to build steel landing craft.

This contract necessitated an expansion of the yard and several acres of ground near the site of the main boatyard were chosen as the spot for the new steel section. Much equipment was required to send the small prefabricated landing craft down the production line, and this equipment was hurriedly purchased by the company. Very few experienced welders were to be found in this vicinity of wooden ships, so a special welding school was started and to date, many skilled welders have come out of The Greenport Basin & Construction Co. school. The entire Steel Section is under the direction of Ted Brigham, Jr., son of the president of the boatyard. Already many Tank Lighters have gone down the ways to take part in the various theatres of war from North Africa to the Solomons. The company may well consider this new venture in building boats of steel a successful one. The production line is efficient and speedy, and the machinery runs smoothly along under the skilled hands of the men.

WELDING PLOWSHARES

A boon to American farmers is Amsco Farmface, a hard-surfacing welding rod manufactured by the American Manganese Steel Division of the American Brake Shoe Co., Chicago Heights, Ill.

A small illustrated 6-page booklet, which is yours for the asking, tells how effectively and cheaply plowshares and other implement parts subjected to wear can be reconditioned by Amsco Farmface. It is made both for torch and arc welding, and having an iron base, it sweats onto rolled or cast steel and cast iron with unusual ease. It adheres closely and resists cracking.

The booklet points out that it also is valuable in hard-surfacing harrow disks and teeth, lister shares, corn planter runners, cultivator spades and sweeps, ensilage cutter blades, threshing machine teeth and many other implement parts that receive severe wear.

STAINLESS STEEL ELECTRODES

The new comparable chart of stainless steel electrodes is published by the Alloy Rods Company, manufacturers of stainless steel electrodes. The chart gives a list of the rods manufactured by each company. Copies of this chart may be obtained by writing direct to the Alloy Rods Co., York, Pa.

ELECTROLOY ALLOYS for RESISTANCE WELDING ELECTRODES and DIES

Spot
Seam
Butt
Flash
Projection

ELECTROLOY ALLOYS were developed specifically for the resistance welding industry. ELECTROLOY ALLOYS cover the full range of physical properties necessary to the manufacturers and users of resistance welding equipment.

Our engineers will be glad to make recommendations for your special electrodes. Submit samples or specifications.

Catalog and prices available on request.

THE ELECTROLOY COMPANY, Inc. 1600 Seaview Avenue, BRIDGEPORT, Connecticut

THE WAR RECORD OF SIL-FOS AND EASY-FLO

points the way to profitable post-war metal joining

The war record of SIL-FOS and EASY-FLO is remarkable in both range and results.

These low-temperature free-flowing silver alloys have provided the speed and reliability so vitally needed in joining ferrous, non-ferrous and dissimilar metals on literally thousands of jobs involved in the production of shells, ships, tanks, planes, guns and a host of other war equipment.

On most of these jobs, SIL-FOS and EASY-FLO have multiplied output many times, saved tons of vital metals and thousands of man-hours — producing superior joints and greatly reducing costs in the process.

Particularly is this true in the numerous cases where methods of heating, jigging and handling have been used to reap the full benefit of the exceptionally fast brazing action of these alloys.

The revolutionary speed, reliability and economy of SIL-FOS and EASY-FLO brazing are sure to be a valuable asset in the competition of post-war business to all manufacturers who capitalize them. If you are not familiar with these alloys and the results they produce — now is the time to get the facts. Get them at our exhibit at the Metal Show, or by sending for **BULLETIN 12-A** which gives the complete story. Write for your copy — now.

HANDY & HARMAN

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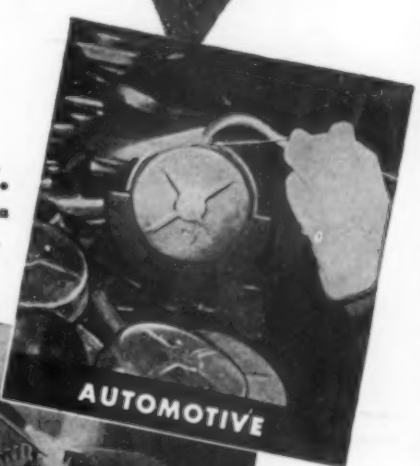
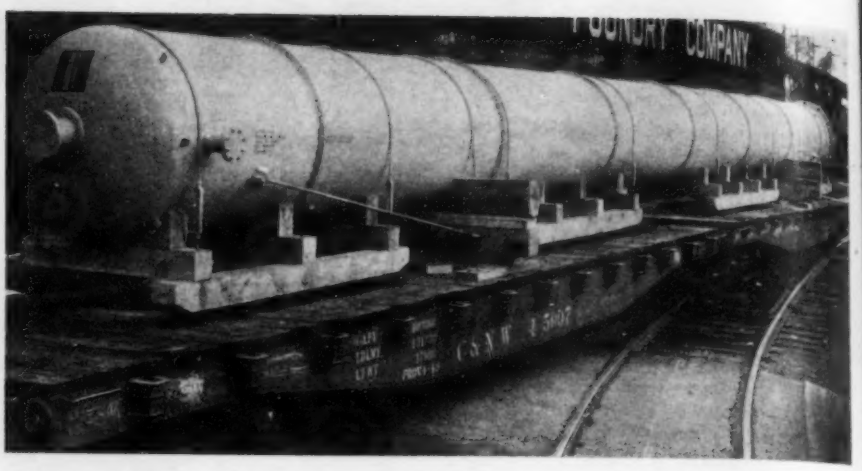


WELDER'S VEST POCKET GUIDE

The Hobart Brothers Co. have prepared a handy and valuable "Vest Pocket Guide" that is a "MUST" on every welder's list.

Its pictures clearly show and explain what is wrong with different types of faulty welds, and how to correct these faults. It suggests and illustrates all kinds of joints, fillet welds and how to cut electrode waste. Explains the 3 essentials of Proper Welding Procedure . . . completely explains and illustrates Welding Symbols . . . Trouble Check Chart on welding machine troubles. A how-to-find list and handy reference information on decimal equivalents.

Sent free to all welders writing to The Hobart Brothers Co., Troy, Ohio, requesting "Vest Pocket Guide for Welders EW-95."



Bubble Towers Constructed at A-C-F Milton Plant for Shipment to USSR

LIGHT BENCH-TYPE ELECTRIC SPOT WELDERS

The Eisler Engineering Co., Newark, N. J., for the past 24 yr. designing and building all forms of automatic resistance welding machines in sizes from 1/4 kva. up to 300 kva., has just issued a profusely illustrated 28-page special Bulletin No. 93-W-43 describing the specific line of the popular small spot welding machines manufactured by the company.

Operating principles, typical standardized arrangements and special applications of these practical machines, particularly suitable for continuous production in assembly work and widely used in the manufacture of radio tubes, incandescent lamps, optical, jewelry, novelties, sheet metal and wire work, are explained.

Simultaneously the Eisler Engineering Co. issued an 8 full-page illustrated Bulletin No. 92-BW-2 methodically listing all features, applications and operations of available types and sizes of small and heavy duty butt welders manufactured by the company and especially designed for welding of wires as low as 0.008 in. diameter of tungsten, molybdenum, nickel and copper—particularly used in the production of electronic tubes. The manual also shows examples of butt welders combined with contactor and timer suitable for wire drawing plants.

BLIND DATE WITH A CONVOY

"Pressure Vessels required for Russian program. This project greatest urgency and top priority. Extremely important to war program you accept these orders and ship on required dates even though this delays other work."

Such was the message received early in June from the War Production Board by the Milton plant of American Car and Foundry Co., at that time busily engaged in building tank cars and storage tanks for the transportation and storage of petroleum products and other liquefied commodities.

The message was a challenge to Works Manager Bill Hindman and his staff who at once cleared the decks for action. Where 1 crane had been sufficient to handle tanks, 4 cranes were now necessary and Hindman enlarged his perspective accordingly to handle these heavyweights in the shop. The result was that the 5 units were completed in the short space of a few weeks. Each one was lifted by 2 gangs of 4 cranes, loaded one each on a flat car, and mounted on swivel blocks to take care of the railroad curves; and sent on its way to keep a date with a convoy headed for the U.S.S.R.

The bubble towers were of a new design, one of the largest being 105 ft. high, 10 ft. and 6 in. wide and weighed 50 tons. The technique developed by the Milton plant in the past few years in the use of automatic submerged melt electric welding process as applied to I.C.C. 105 Class tank cars, came to the rescue on this project of greatest urgency and top priority.

The bubble towers constructed by this process received the A.S.M.E. Code U-68 pressure vessel quality of welding.

ENGINEERS SEE LAUNCHING OF SHIP

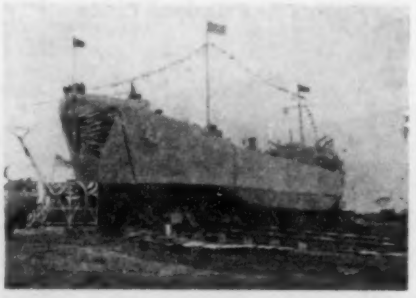
Members of the Western Society of Engineers, the Chicago Chapter of the American Society of Civil Engineers, the Chicago Engineers' Club, the Rensselaer Alumni Association, Chicago Local and the Commercial Club of Chicago were invited to witness the launching of a tank landing ship at Seneca on June 5th. The group made the trip by train, returning to Chicago immediately after the ceremonies.

Merle J. Trees introduced the speakers, calling first on Commander Paul S. Goen, who spoke for the U. S. Navy as follows:

"A study of the newspapers makes one realize that the type of craft being built in this prairie shipyard will be used by the Unites States and our Allies all over the world. Just last week we all saw pictures in newspapers of certain landing craft being used in the invasion of Attu Island in the Aleutians.

"More than likely several of the 13 craft you have already delivered are standing by now to undertake much more ambitious landing operations than the one just completed at Attu. The operations in which your ships will take part are the most important and the most dangerous of any to be undertaken in this war—namely, the successful landing of powerful striking forces on hostile foreign shores. Many troops and much fighting equipment will be carried by your ships to deal decisive blows to the Axis and bring us closer to complete Allied victory.

"The Supervisor of Shipbuilding and his staff are all as proud as you are to be identified with ships of such major importance, and I am here today to thank you for the splendid way in which you are accomplishing your shipbuilding program.



One of a Large Number of Ocean-Going Tank Landing Ships at the Seneca Shipyard of the Chicago B. & I. Co.

NEW COOLANT COOLER BULLETIN

A two page, illustrated technical Bulletin No. 75-AC describing the new Frostrode coolant cooler has just been released by Frostrode Products, 19003 John R Street, Detroit 3, U. S. A. Designed for accurate temperature control of coolants and lubricants in machine processing, these portable compact, durable units complete the equipment needed for many present day precision production requirements. Minimum work distortion due to heating in grinding, cutting, turning and other operations is now possible for the first time, it is claimed.

HELPING TO SOLVE TODAY'S WARTIME PRODUCTION PROBLEMS

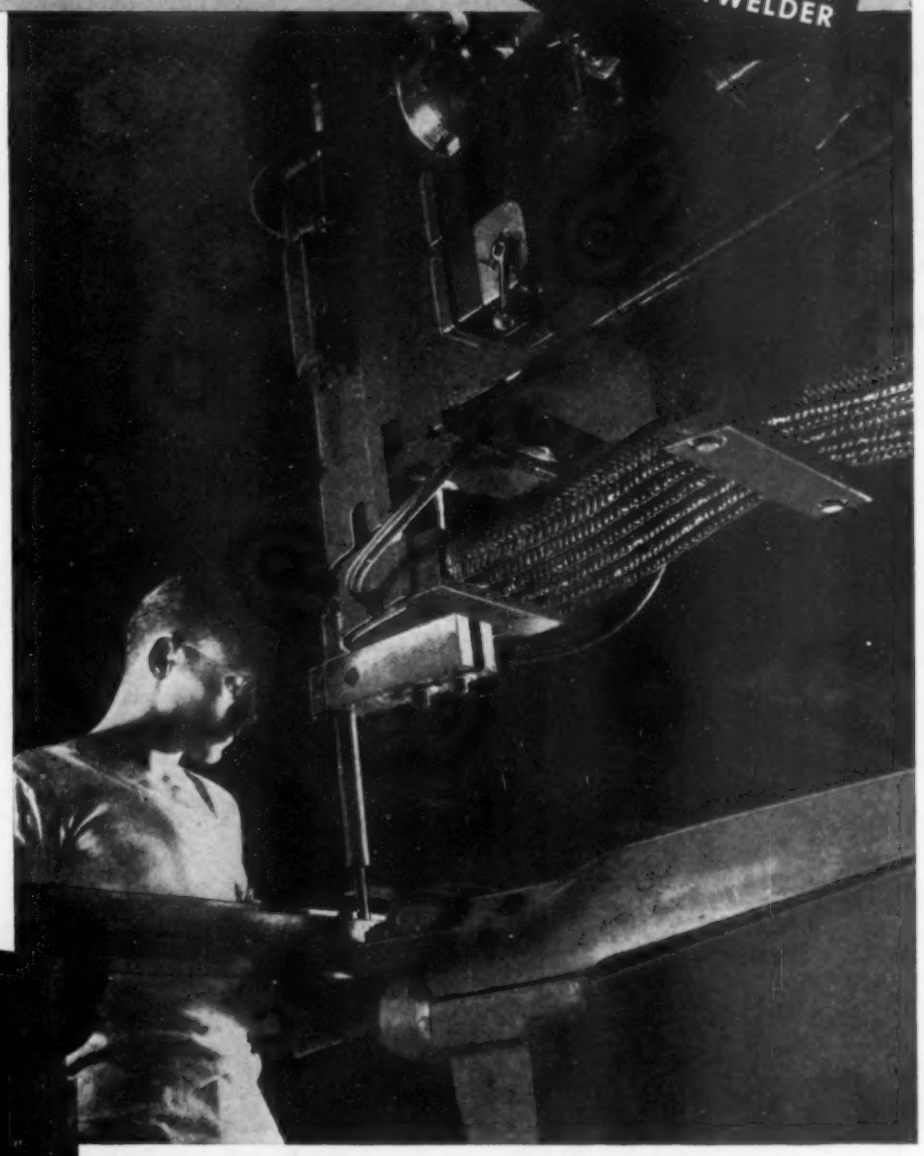
Critical Extrusion Problem Solved by Martin Engineers

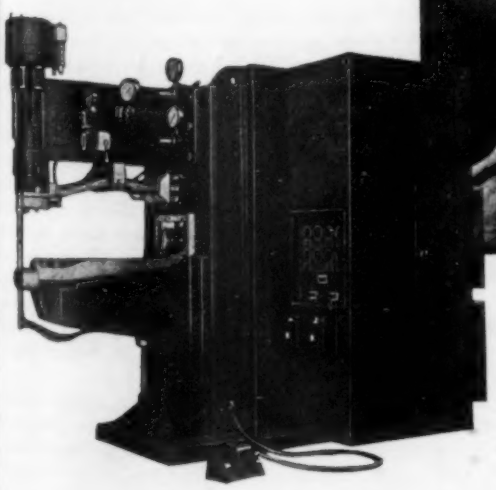
. . . ON THE WORLD'S LARGEST SPOTWELDER

Faced with a severe shortage of extruded parts which threatened the production of Marauder bombers, Martin tool engineers found the answer in the *spotwelding* of heavy aluminum stampings. Parts such as tank door ribs, wing ribs, spars, longerons and fuselage formers are now built up from sheet metal parts in gauges hitherto thought impossible to spotweld.

The huge machine doing this job, has been designed and developed by Sciaky to weld up to two thicknesses of .187" aluminum. Features which have proved so successful in the welding of lighter gauges are employed. The tremendous power required (a flow of 100,000 amperes) is compensated for by the use of STORED ENERGY, which delivers instantaneous welding current without disturbing the plant's power system. Precise control of pressure is accomplished by the Sciaky patented VARIABLE PRESSURE CYCLE which regulates pressures up to 12,000 lbs. in an automatic sequence.

While this machine is being operated twenty hours per day on production, experiments are being conducted to prove its adaptability to steel armor plate, as well as other heavy aluminum parts.





TYPE PMCO5S-1 SCIAKY ELECTRIC RESISTANCE SPOTWELDER, 240 KW. Welding capacity: Aluminum and other alloys or corrosion resisting steels in thicknesses of from .040" minimum up to and including .187" maximum. Speed: 40 spot welds per minute on two thicknesses of .040" of light alloys.

SCIAKY BROS.

Manufacturers of a Complete Line of
A.C. and D.C. Electric Resistance Welding Machines
4915 W. 67th Street, Chicago, 38, Illinois

NEW PRODUCTS

The Society assumes no responsibility for the validity of claims in this Section

HELIUM-SHIELDED ARC WELDING

The development of both manual and automatic arc-welding equipment specifically designed for the welding of magnesium, magnesium alloys, aluminum and other high-strength light alloys under a protective shield of helium gas, has been announced by C. I. MacGuffie, Manager of General Electric's Electric Welding Division.

According to Mr. MacGuffie, the availability of such equipment should make possible the greatly extended use in war production of the lighter metals whose welding demands precise control of concentrated heat and protection of the molten metal from the oxidizing effect of oxygen in the air.

The development of the new equipment is based on research work initiated some time ago at General Electric's welding laboratory and intensified recently, in view of the development and wider use of the light alloy metals for war production. The basis of this research was the pioneering work done years ago by G-E engineers, H. M. Hobart and P. K. Devers, who discovered that fusion welding could be done in atmospheres of helium and argon using tungsten and carbon electrodes.

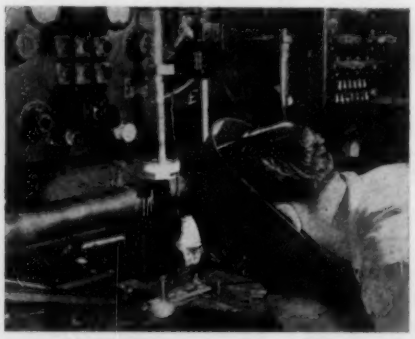


Fig. 1—Magnesium Plate Being Welded at G-E Welding Laboratory. Shows Major Part of Equipment

A hint of things to come in the arc welding of magnesium and other hard-to-weld metals is given by an automatic unit (Fig. 1) now in use at the G-E welding laboratory. Completely automatic after preliminary adjustment, this equipment makes a smooth, clean weld (Fig. 2) under a shield of helium gas at rates up to 40 in. per minute on $^1/_8$-in. stock, for example. Figure 3 shows a close-up view of the welding of magnesium plate.

Substantially the same as a G-E unit now installed at the plant of a large producer of magnesium, this machine incorporates a new electronic motor control which enables the equipment to hold the proper arc length even while the arc climbs and descends inclines, such as

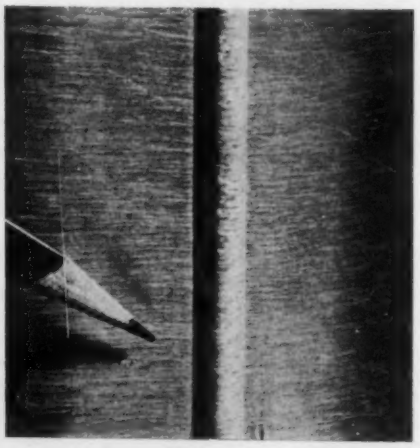


Fig. 2—Close-Up of $^1/_8$-In. Magnesium Plate; Automatically Welded with G-E Helium-Shielded Arc-Welding Equipment at 24 In. per Minute

encountered, for example, in welding curved-surface parts.

Referring to Fig. 1, the filler metal (magnesium, here) is unreeled into the work at the correct angle through the small nozzle rod at the lower left. The tungsten electrode used to start and maintain the arc extends through the center of the rod that is perpendicular to the work and the helium gas is fed in around the electrode.

The rate at which filler metal is fed can be adjusted to a constant uniform feed into the arc, or a supplementary control can be used to feed wire into the arc, withdraw it and then feed it in again—all on a predetermined cycle.

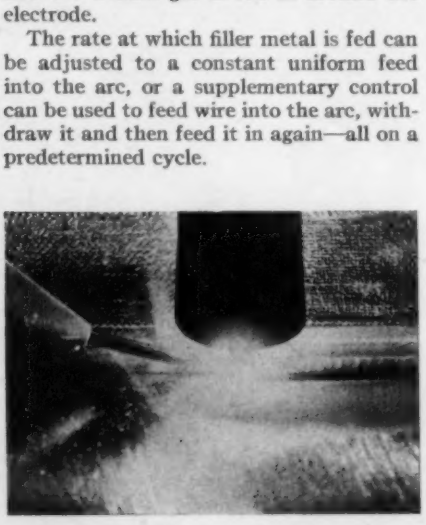


Fig. 3—Close-Up View of Welding Operation. Shows Helium Shield

The heart of the manual helium-shielded arc-welding equipment is a specially designed electrode holder which is arranged to hold either a tungsten or a carbon electrode, to conduct the welding current to the electrode and to surround the electrode with a stream of helium gas. The source of d.-c. power for both manual and automatic welding is a standard G-E d-c. arc-welding machine.

Supplies of helium have been made availabe by the Bureau of Mines for welding, especially for use in war production. A number of distributors of compressed gases in different parts of the country are now obtaining helium gas from the Bureau of Mines for resale.

WELDING FLUID REDUCES FUMES 30%

On many production welding jobs welders dislike the inhalation of fumes, especially those created from welding of galvanized iron or zinc-coated sheets. The problem is not solved by the decision to insist upon wearing respirators, for under the conditions they work a respirator handicaps their operations.

A report released by Dr. E. A. Arnold discusses a comparative laboratory test that was made with galvanized iron and No-Spat Welding Fluid manufactured by the Midland Paint & Varnish Co. of Cleveland.

After the laboratory apparatus had been set up duplicate pieces of galvanized iron were tested. The only difference in these test samples was that one series was treated with No-Spat Welding Fluid, while the other series was untreated. A competent welder using an oxyacetylene torch did the actual welding work.

As a fair comparison each weld was stop-watched to 2 min. and the torch removed after which the accumulator pump was allowed to operate an additional 2 min. to accumulate all the fumes and vapors.

A comparison of the vaporization showed that on untreated galvanized iron each 2-min. weld vaporized 0.107 gm. of zinc. While on the galvanized iron treated with No-Spat only 0.074 gm. of zinc was obtained through the analysis and assay. The conclusion of this test would indicate that welding fumes and vaporization of zinc can be materially reduced at least 30% by the application of a chemical solution like that which was tested,

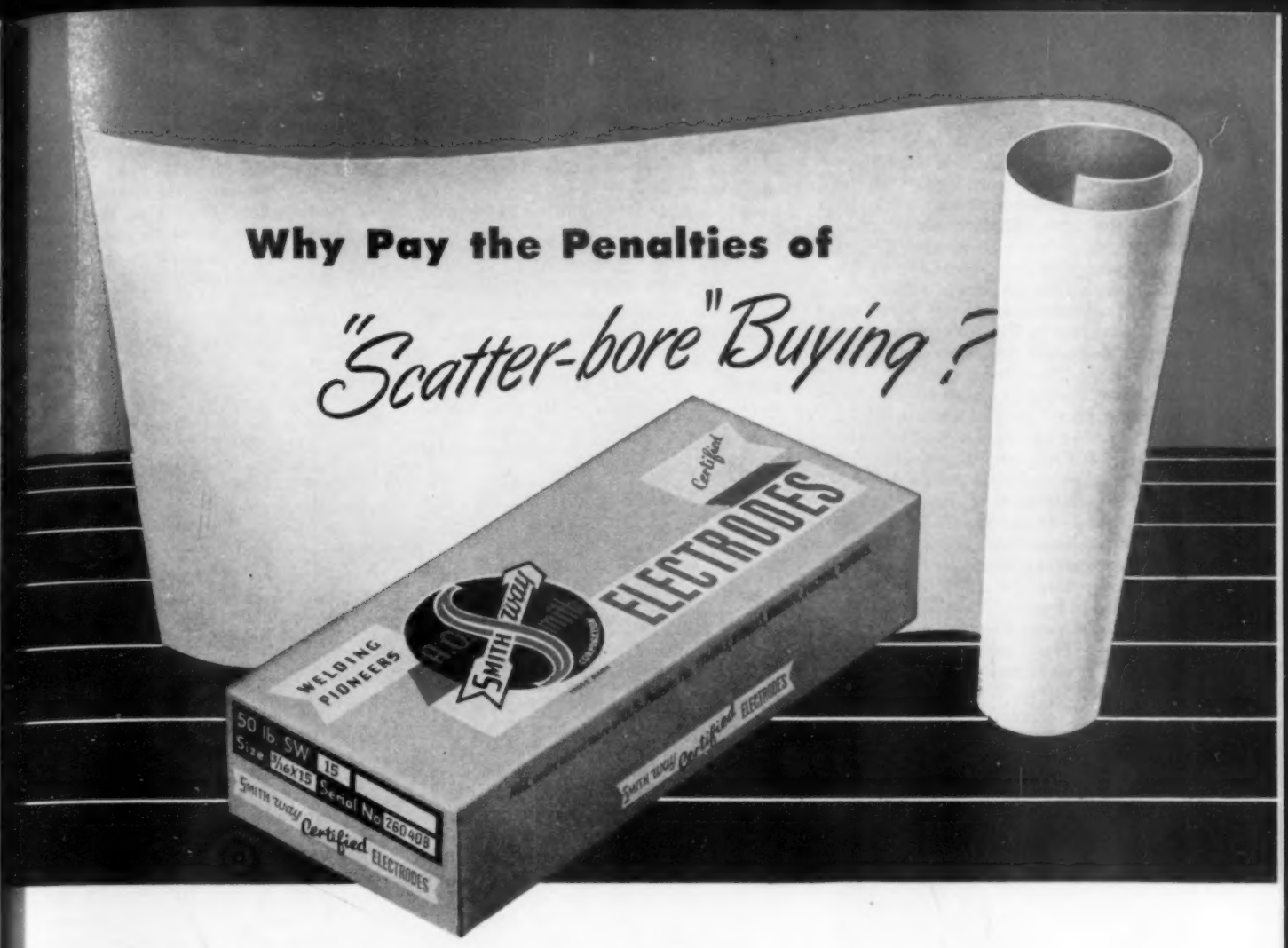
---

FLUX AND SPATTER—PROOFING COMPOUND

Protect-O-Metal No. 2 not only protects work surfaces from spatter but also has important fluxing qualities which improve the operation of any electrode and provide neater, stronger welds.

Protect-O-Metal is brushed or sprayed *directly into the seam* to be welded and on surrounding surfaces where spatter usually collects. During the welding operation the compound in the seam fuses in with the molten metal removing all oxides and impurities from the weld. Porosity is prevented and official laboratory tests show that the weld's tensile strength is increased by over 2000 psi. (on $^3/_8$-in. boiler plate) where Protect-O-Metal is used.

After welding, all spatter, surface oxide and remaining compound are removed *quickly* and *completely* with a damp cloth. A spotless, spatter-free finish results, ready for painting if desired. G. W. Smith & Sons, 79 S. Sperling Ave., Dayton, Ohio.



For years it has been common practice among buyers of welding electrodes to purchase from several different sources. We can understand that—for we remember when it was necessary to buy one type of electrode from one supplier, another from another, and so on, in order to get the best electrode for each and every type of welding.

But that time has passed. "Scatter-bore" buying is no longer necessary.

Today the line of SMITHway Certified Welding Electrodes includes electrodes for a wide range of welding applications. Each type of SMITHway electrode is equal to or better than any competitive type on the market. Therefore, you gain two distinct advantages by concentrating your purchases in this one line. First, and of most importance, you get the electrode that gives you the best results for your particular application. Second, you get the lowest prices by taking advantage of the highest single shipment allowance.

Mild Steel . . . High Tensile . . . and Stainless Steel
WELDING ELECTRODES
made by welders . . . for welders

SMITHway Welding Monitor *cuts training time . . . trains better welders in less time.*

SMITHway AC Welding Machine *eliminates arc blow, reduces spatter, increases production.*

A.O. SMITH Corporation

MILWAUKEE • WISCONSIN • HOUSTON • TEXAS

SPAGHETTI SPEEDS WAR PRODUCTION

Spaghetti—uncooked but otherwise the same spaghetti you eat—has been put to work to speed the manufacture of electronic tubes used for war communications.

With their eyes still wide in amazement, veteran production men at the Westinghouse Lamp Division recently told how William A. Hayes, young electronics engineer, discovered this novel war substitute that cuts by 75% the time required to assemble certain tube filaments and reduces the need for critical steel.

A stick of spaghetti placed inside a tiny wire coil supports the coil while it is being welded, according to D. D. Knowles, manager of electronics engineering. A piece of steel formerly was used as the support but it was difficult to remove. Spaghetti can be burned out in a flash. Because of the important savings in time, man power and materials, Mr. Hayes has been recommended for a WPB Award of Individual Production Merit. His method produces 50% more filaments and at the same time allows assembly operators to spend part of their time on other production jobs.

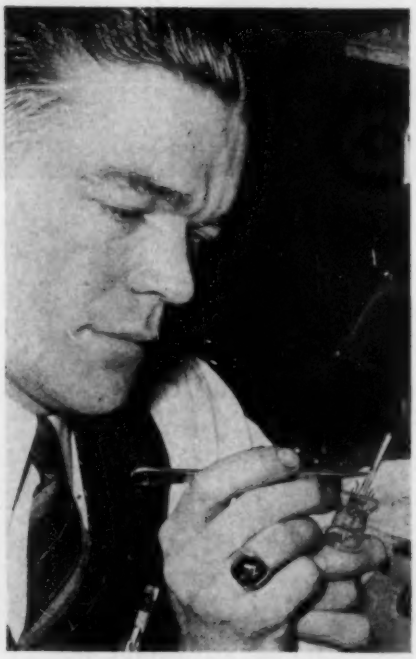


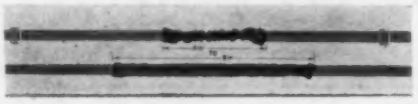
Fig. 1—Spaghetti Breaks Bottleneck

William Hayes, young electronic engineer at the Westinghouse Lamp Division, has broken a production bottleneck by using ordinary spaghetti to speed the assembly of radio tube filaments 75%. He is shown examining a short stick of the uncooked food which is inside the wire filament coil where it served to support the coil during a welding process.

ELASTIC-ACTION HEADBAND

A new resilient non-rubber elastic-action headband called "Holdtite" is claimed to be not only a Victory replacement but actually superior to rubber headbands, according to the manufacturer, Carter-Lockard Co. of 225 West 11th St., Los Angeles, Calif.

As the "Holdtite" headband has the stretch of elastic, it is highly efficient for workers who wear goggles or respirator; in fact, wherever rubber-elastic headbands have been in use. The headband is easy to adjust for comfortable fit and the

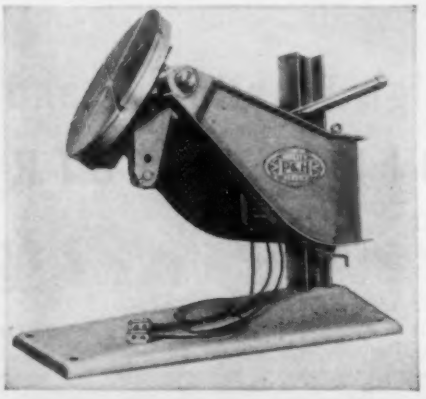


maker outlines that once set the headband cannot loosen as there is no elastic to get old, weak and overstretched.

The new product sells for 25¢ each and is ready for immediate delivery.

P&H BRINGS OUT NEW WELDING POSITIONERS

With the background as first builders of welding positioners in the U. S., and long-time manufacturers of P&H welders and electrodes, Harnischfeger Corp. is currently introducing a newly designed line of work—positioning machines. Promising more actual arc time for welding production lines, as a result of greater flexibility and ease of operation, the P&H design is marked by numerous refinements. An outstanding feature, achieved by special design, is the dual capacity rating of each model. For example, the WP-6 in the 6000-lb. class, handles loads up to 6000 lb. maximum and also has a secondary capacity of 9000 lb. maximum. Standard models are being made in dual capacities up to 24,000 lb. Construction is for constant heavy-duty service, employing all-welded rolled steel throughout, with strong box-type mounting. Table top areas are larger than usual. By placing the elevator column farther back, the design provides greater clearance for handling large weldments. Operating mechanisms set a new standard of simplicity and safety in compact design. Self-locking worm gear and spindle drive on tilting motion prevent upsets, with limit switch and adjustable stop brackets, giving additional safety when extreme tilting is necessary. Table turning is by pinion from totally enclosed flood-lubricated gear case to bull gear to which the table top is securely bolted. The bull gear is permanently held in position by a one-piece safety head king pin. Table can be quickly removed for bolting special weldments or fixtures direct to bull gear. Control of table motions is by remote control with individual magnetic push-button stations to two separate motors for tilting and turning. A roller equipped yoke with self-locating stops provides free-running elevation of table by hoisting. Working levels are easy to find. All models are supplied for a.c. or d.c. and with portable or in-the-floor mounting. Auxiliary equipment available includes self-leveling platform for welding operator, variable speed for table turning, power elevation, higher than standard elevator column, etc. For descriptive literature, address Welder Div., Harnischfeger Corp., Milwaukee 14, Wis.

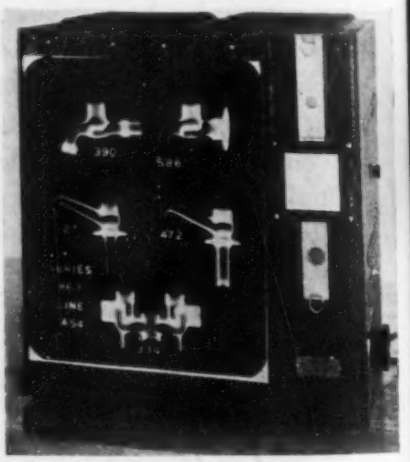


New P & H Model WP-6 Welding Positioner Featuring Dual Capacity. Models in Capacities Up to 24,000 Pounds

HIGH-INTENSITY X-RAY ILLUMINATOR

The Kelley-Koett Manufacturing Co. recently announced a new High-Intensity Industrial Illuminator. Providing four times more illumination than heretofore available, it permits observation of film detail formerly missed with weaker light sources.

This increased intensity also makes it possible to use films of greater density with the resultant improvement in radiographic contrast. The High-Intensity Illuminator raised the usable density from 1.5 to more than 4.0.



The view box is equipped with a Variac control which affords a stepless increase in intensity by varying the voltage from 0 to 110 v. By means of this control the exact amount of light necessary to observe details at various film densities can be obtained.

The illuminator is a full 14 x 17 in. so that even the largest film can be viewed without repositioning. Masks are used to reduce the illuminated surface when films smaller than 14 x 17 in. are examined. Another convenience is the wet film hanger that allows films to be observed immediately after they are developed.

Films are protected from the heat of the photoflood lamps by the cold front. A

"YOU CAN LEAD A HORSE TO WATER"—

Stubborn, some horses. But intelligent, too!

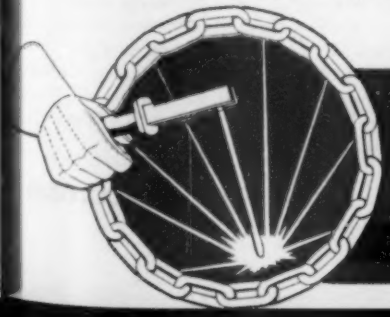
That's why we say the fellow who really uses the brain he was born with . . . has "horse sense."

We think many of our customers, who know that welding is a *metallurgical problem,* show that kind of judgment by insisting on McKay Shielded-Arc Welding Electrodes. Because the solution to metallurgical problems starts in the laboratory . . . with microscopes and test tubes and painstaking analyses. McKay Electrodes come from the "researched line" . . . the only line, to our knowledge, developed in a great nationally known research institute.

And men who specify McKay Commercial Chain (and McKay Tire Chains for their automobiles, too) show good judgment in buying the product evolved over 60 years of manufacture since the days when chain was sweated out over a simple blacksmith's forge.

We like "horse sense."

GENERAL SALES OFFICES: YORK, PA.



THE McKAY COMPANY
PITTSBURGH, PA.

WELDING ELECTRODES . . . COMMERCIAL CHAINS . . . TIRE CHAINS

heat-absorbing glass baffle and cooling fans which circulate 900 cu. ft. of air per minute, dissipate all excess heat even during continuous operation.

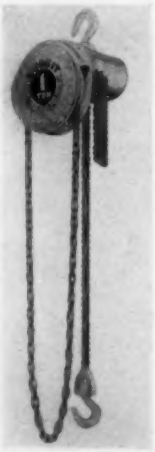
A 3-in. spot with four times the intensity of the large front surface permits intensive examination of critical areas on the film. Although the 3-in. spot provides such intense illumination, a specially constructed air-cooled water cell prevents a rise in front surface temperature even during continuous operation.

Complete details may be obtained by writing for Kelley-Koett Publication F-11. The Kelley-Koett Manufacturing Co., 212 W. 4th St., Covington, Ky.

"BUDGIT CHAIN BLOCKS"

"Budgit Chain Block" Division of Manning, Maxwell & Moore, Inc., Muskegon, Mich., have just announced a new line of high-speed, spur-geared chain hoists in capacities of 1/4 to 2 tons lifting capacity, to be marketed under the trade name of "Budgit Chain Blocks."

They are of a completely new design and different from any other spur-geared hand-operated hoist. Light weight is a feature of their design. The 1/4- and 1/2-ton lifting capacity hoists weigh 48 lb., the 1-ton hoist weighs 59 lb. and the 2-ton hoist but 81 lb.

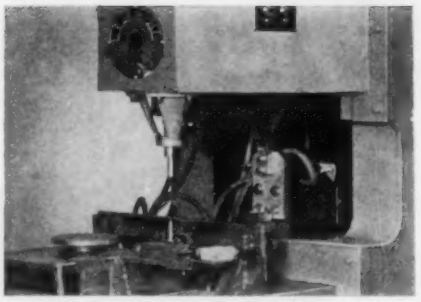


Patterned after their electrically operated "Budgit" Hoists they have included in their design spur gearing, anti-friction bearings on all shafts, roller type lift chain.

Other outstanding features are that the automatic load brake and the entire mechanism operate in a grease-packed sealed enclosure; a stamped steel hand chain wheel housed in a steel enclosure; a chain guide that prevents the hand chain from "gagging" or fouling the wheel and a high efficiency that results in fast and easy operation.

RIVETING WITH A WELDER

An ingenious adaptation to other uses of equipment originally developed for resistance welding is in the riveting of stamped assemblies. The machine used looks like a spot-welder—as a matter of fact it was developed by Progressive Welder Co., Detroit, builders of resistance welding equipment.



Close-Up Photo of Machine Showing Indexing Table and "Electrodes"

Equipped with an indexing table it hot-upsets and rivets in place the vanes of hydraulic flywheels. The ends of the vanes stick through holes in the faces of assembly rings. The "electrodes" are brought down under pressure against them, heating and at the same time upsetting these ends to rivet the parts securely.

The right amount of heat is obtained by means of conventional welding timers combined with a lower current density than would be used for welding.

ULTRA HIGH SPEED MOTION PICTURES

Here is news for all physicists, engineers, research directors and others responsible for the development of war and postwar products.

Camera equipment capable of taking movies at the rate of 3000 pictures per second, with all accessories, and a trained photographic engineer is now ready to help you in your particular engineering problems. Specialized service available when you need it and where you need it! No costly apparatus or unnecessary personnel is required for this research aid. McLarty Business Films, 986 Ellicott St., Buffalo 8, New York.

1940–42 LINCOLN FOUNDATION STUDIES IN ARC WELDING NOW AVAILABLE IN BOOK FORM

Studies in Arc Welding—Design, Manufacture and Construction, first edition, published by The James F. Lincoln Arc Welding Foundation, Cleveland, Ohio, includes over 1000 illustrations, bound in semi-flexible simulated leather, 6 × 9 in., with 1295 pages, fully indexed, gold embossed.

Ninety-eight outstanding papers on arc welding, submitted by trained technicians and engineers in The James F. Lincoln Arc Welding Foundation's 1940–42 Industrial Progress Award Program, have been edited and published in what is said to be the most comprehensive and complete collection of design studies on arc welding published since the Foundation's first volume was issued in 1939.

The volume is the result of the careful editing of papers on arc-welding practice representing the work of 113 engineers, designers, works managers, superintendents, executives, foremen and other technicians, each of whom applied himself individually to a specific design study involving arc welding.

There are 1007 illustrations, the majority of which are actual photographs of welding procedures. Each study includes designs, calculations, procedures and other pertinent information which show how the advantages attributed to arc welding are obtained.

Many of the studies involve plants now engaged in war production but the principles and practices reported in individual studies are also applicable to industrial design and manufacture in the postwar era ahead.

The contents of the book are arranged in nine sections with 98 chapters. Each chapter covers a specific design subject; each section covers a particular field, such as aircraft, railroad, etc.

Studies in Arc Welding is priced at $1.50 per copy, postpaid anywhere in the United States, $2.00 elsewhere. Copies may be secured by writing The James F. Lincoln Arc Welding Foundation, P.O. Box 5728, Cleveland, Ohio.

OFFICE OF WAR INFORMATION WAR PRODUCTION BOARD

The use of certain critical materials in the manufacture of spot welding electrodes is restricted and simplification and standardization practices are established by General Conservation Order L-318 issued Sept. 7 by the War Production Board.

Fitting ends for spot welding electrodes must be machined for specified sizes, except when the buyer certifies that the electrodes are needed for use in pulsation welding. The manufacture of straight spot welding electrodes is limited to overall lengths and maximum diameters as specified in Schedule A attached to the order.

Provisions governing the use of critical materials prohibit the use of tungsten, molybdenum or metallic mixtures containing these metals, except in electrode facings and inserts; and permit the use of copper base alloys of cadmium, chrome, beryllium-cobalt and beryllium-nickel only to the extent specified in Schedule B.

Effective date, October 7, 1943; materials in producers' hands on September 7 are exempt from the restrictions on critical materials.

PORTABLE ELEVATING TABLE

A new folder describes how on dozens of jobs around the shop, the Hydraulic Elevating Table will help speed up production, cut down accidents, prevent damage to equipment and often eliminate need of helpers. It operates *hydraulically*—no ratchets, no gears. The table is elevated by short, easy strokes of the foot pedal—and lowering controlled by foot release pedal. When table top rotation is desired, simply turn knob to disengage locking key that normally holds table top from rotating. As table and base are of same size, unit may be pushed close to a machine without interference. Lyon-Raymond Corporation, Material Handling Equipment, 1340 Madison St., Greene, N. Y.

For more welding production—faster

. . . use the WILSON "BUMBLEBEE" AC Welder

You can get 15% to 30% faster welding—hence more welding production per work day—with the Wilson "Bumblebee" AC welder.

That's just one of the reasons why many busy war plants are changing to this sturdy, efficient Wilson AC machine. In addition the "Bumblebee" provides these three timely advantages:

1. ***Better quality welds*** **because there's virtually no arc blow.**
2. ***Savings in power*** **as much as 30% thanks to the "Bumblebee's" high electrical efficiency.**
3. ***Reduction in power charges*** **due to built-in capacitors.**
4. ***Easier maintenance*** **because there are no rotating parts.**

The "Bumblebee" is made in 300 and 500 ampere sizes. Wilson has a complete line of AC machines from 100 to 1000 amps. capacity. For full information write today to Wilson Welder & Metals Co., Inc., 60 East 42nd Street, New York 17, N. Y.

FOR BEST AC WELDING WILSON 530 ELECTRODE

Perfect teammate for the "Bumblebee" is the all-position AC electrode—Wilson No. 530. It produces high quality welds to conform to these specifications:

AWS Filler Metal Spec. E6011.

Navy Bureau of Ships, Spec. 46E3, Grade III, Class I.

A.S.M.E. Boiler Code, Para. U68.

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In the U. S. A.: **WILSON AC WELDERS — *distributed exclusively through Air Reduction Sales Company***

In Canada: **G. D. Peters & Co. of Canada, Limited • Birks Bldg., Montreal**

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August 1 to August 31, 1943

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Melchionda, Michael C. (D), 278 E. Eagle St., East Boston, Mass.
Walcott, Leonard E. (C), Box 321, Lynfield Ctr., Mass.
Worrell, C. Y. (C), Box 508, Manchester, N. H.

CANADA

Buckle, John T. (B), 253 Durand St., Sarnia, Ont., Canada.
Buell, William F. (C), Canadian Allis Chalmers Co., Lachine, Quebec, Canada.
Voyer, Joseph Jean Paul (D), 966 Gilford, Montreal, Quebec, Canada.

CANTON

Rothschild, Gilbert R. (C), 1227 Copley Rd., Akron, Ohio.
Sukosd, Albert (D), 2006 St. Elmo Ave., N. E., Canton, Ohio.

CHICAGO

Comstock, Harry H. (B), 1951 W. Birchwood Ave., Chicago, Ill.
Damarin, Fred L. (B), 7804 S. Paxton Ave., Chicago, Ill.
Frisch, George (B), 1400 Wabansia Ave., Chicago, Ill.
Galvin, Thomas A. (B), National Cylinder Gas Co., 4700 W. 19th St., Station 50, Chicago, Ill.
Gruca, Edward P. (B), 10841 S. Forest St., Chicago, Ill.
Hough, Frank B. (C), 2207 Elisha Ave., Zion, Ill.
Luga, Theodore F. (C), 4734 W. Grace St., Chicago, 41, Ill.
Olson, John F. (B), 7928 Sunset Dr., Elmwood Park, 35, Ill.
Steele, Charles William (B), National Cylinder Gas Co., 4700 W. 19th St., Station 50, Chicago, Ill.
Wilson, S. J. (B), National Cylinder Gas Co., 4700 W. 19th St., Station 50, Chicago, Ill.

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Kissick, Russel P. (C), 569 Greenwell Ave., Cincinnati, Ohio.
Payne, Joseph A. (C), 7628 Greenland Ave., Cincinnati, Ohio.
Shafer, Edward R. (C), 101 Blackburn Ave., Latonia, Ky.
Smith, F. H. (C), 2011 Florence Ave., Cincinnati 2, Ohio.

CLEVELAND

Johnson, Sheridan R. (B), 500 W. 5th Ave., Warren, Pa.

COLUMBUS

Ebert, Harry W. (F), 534 Carpenter St., Columbus, Ohio.
Golder, Morton H. (F), 61 West Frambes, Columbus, Ohio.

CONNECTICUT

Hitchcock, George A. (B), 220 Maple St., New Britian, Conn.
Parks, Charles H. (B), The Bullard Co., 286 Canfield Ave., Bridgeport 2, Conn.

DETROIT

Chatterton, R. Bruce (B), P. R. Mallory & Co., 3026 E. Grand Blvd., Detroit, Mich.
Miller, Orville V. (B), P. R. Mallory & Co., 3026 E. Grand Blvd., Detroit, Mich.
Ramsay, James G. (C), 101 W. Margaret, Detroit, Mich.

HAWAII

Lister, Leonard O. (C), P. O. Box 73, Ewa, Hawaii.

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Davis, Harold A. (C), 505 N. Bancroft St., Indianapolis, Ind.
Hensel, Dr. Franz Robert (B), 4000 Cooper Rd., Indianapolis, Ind.
Holt, Edman Francis (B), 17 N. Whittier Place, Indianapolis, Ind.
Larsen, E. I. (B), 321 E. 36th St., Indianapolis, Ind.
Shetterly, Karl P. (C), 820 E. 21st St., Anderson, Ind.
Smith, Russell F. (C), 114 W. 8th St., Anderson, Ind.

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Ball, Ethan F. (C), Bethlehem Steel Co., Bethlehem, Pa.
Barron, P. H. (B), 684 Northampton St., Easton, Pa.
Beitler, Harvey C. M. (C), 924½ S. 7th St., Allentown, Pa.
Bernhardt, Clayton W. (B), 1230 Lenox Ave., Bethlehem, Pa.
Clauser, George G. (B), R. D. 3, Bethlehem, Pa.
Draper, L. D. (C), Hotel Bethlehem, Bethlehem, Pa.
Eichert, William A. (C), 2407 Tilghman St., Allentown, Pa.
Gingrich, H. E. (B), 405 Washington Ave., Bethlehem, Pa.
Harvey, John (C), 56 West Ettwein St., Bethlehem, Pa.
Hess, Raymond S. S. (C), 632 W. Broad St., Bethlehem, Pa.
Jacoby, Russel H., Sr. (C), 2544 Easton. Ave., Bethlehem, Pa.
Jameson, W. H. (C), Fab. Steel Const., Bethlehem Steel Co., Bethlehem, Pa.
Johnston, Sterling (C), 328 E. Broad St., Bethlehem, Pa.
Kunsman, Earl W. (B), Bethlehem Welding School, 46 E. Broad St., Bethlehem, Pa.
McPherson, M. R. (C), R. D. 2, Bethlehem, Pa.
Metz, C. Creighton (C), W. F. Mosser & Son, Allentown, Pa.
Miller, Charles K. (C), 934 7th Ave., Bethlehem, Pa.
Mohr, William H. (C), Lehigh Structural Steel Co., Allentown, Pa.
More, Edgar A. (C), 638 8th Ave., Bethlehem, Pa.
Moyer, Ralph E. (C), 1017 Highland Ave., Bethlehem, Pa.
Schrader, Roland R. (C), 1628 Cloverleaf St., Bethlehem, Pa.
Seiders, George H. (C), 1414 W. Union Blvd., Bethlehem, Pa.
Sheldrake, Charles W. (C), 1622 W. North St., Bethlehem, Pa.
Smith, Clyde A. (B), 942 7th Ave., Bethlehem, Pa.
Snyder, Fred I. (B), Metal Welding Co., 1724 Tilghman St., Allentown, Pa.
Snyder, Henry C. (B), Metal Welding Co., 1724 Tilghman St., Allentown, Pa.
Taylor, Lloyd G. (C), Penn. Power & Light Co., 901 Hamilton St., Allentown, Pa.
Waddell, Frederick C. (C), 523 13th Ave., Bethlehem, Pa.
Weir, Thomas L. (C), 720 Chestnut St., Bethlehem, Pa.

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Cady, P. E. (D), 1067½ Gladys Ave., Long Beach, Calif.
McGrew, Wayne S., (C), 4819 W. 99th St., Inglewood, Calif.
Roberts, Albert C. (B), 1210 N. Keystone St., Burbank, Calif.
Walker, Charles J., Jr. (C), American Bureau of Shipping, Calif. Bank Bldg., Wilmington, Calif.
Woodward, Burton James (B), 1647 E. Mission Dr., Rosemead, Calif.

LOUISIANA

Elbourne, Claude H. (B), 768 Glenmore Ave., Baton Rouge, La.
Nelson, Herman E. (B), 3024 Hiawatha St., Baton Rouge, La.

LOUISVILLE

Armstrong, James N. (C), 3752 Fincastle Rd., Apt. C, Louisville, Ky.
Arnold, Orville (D), 124 E. Ormsby Ave., Louisville, Ky.
Blahut, Albert J. (C), 4232 Vermont Ave., Louisville, Ky.
Borders, James Richard (C), 1426 Christy Ave., Louisville, Ky.
Bowers, Francis M. (C), Box 164, Route 4, Louisville, Ky.
Day, Elmer Charles (D), 529 N. 22nd St., Louisville, Ky.
Doyle, Marion M. (C), 4317 Park Blvd., Louisville, Ky.
Gillette, Audley Lavelle J. (C), 30 Allison Lane, R. 1, Jeffersonville, Ind.
Hardy, Jesse W. (C), McDonald Lane, New Albany, Ind.
Hasch, Ossain D. (C), 418 Wawa Ave., Louisville, Ky.
Hebuer, Sam (C), 815 Spring St., Jeffersonville, Ind.
Henwood, Roy M. (B), 444 E. 57th St., New York, N. Y.
Hochstrasser, R. L. (B), 530 River Rd., Louisville, Ky.
Hohmann, Edward L. (D), American Air Filter Co., 215 Central Ave., Louisville, Ky.
Hunt, Delvin M. (B), Reliable Welding Co., 630 S. 15th St., Louisville, Ky.
Kallin, Fred (D), Shively, Ky.
Kitterman, R. L. (D), Shephardsville, Ky.
Miller, Charles E. (C), 3773 Craig Ave., Louisville, Ky.
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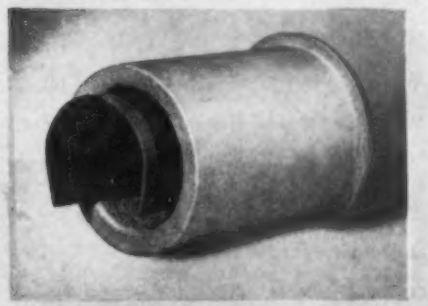
PICKER flexible film holders

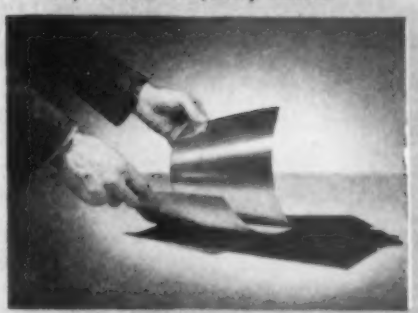
for radiography of curved objects

The difficulty of flexing ordinary exposure holders to sharply curved contours has long been a problem to the industrial radiographer. Picker Flexible Film Holders solve this problem once and for all. They are made of durable black, opaque plastic which can be flexed to small diameters. Each holder consists of a pair of envelopes, one of which slides easily into the other to make a completely light-proof unit, easily loaded or unloaded. The use of these flexible holders appreciably increases the speed and efficiency of radiographing tubular castings and welds with curved or awkward surfaces.

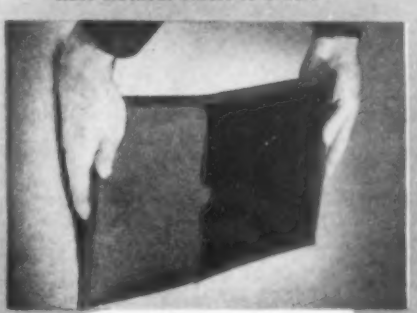
The Flexible Holder, complete with Picker Lead-Alloy Screens and Films, is easily flexed for difficult positions.



Lead-Alloy Screens, together with Films, load freely into inner envelope. Assembly remains completely flexible.



Holders furnished as sets, consisting of inner and outer envelope. Standard sizes stocked; others to order.



PX

Picker X-ray CORPORATION

300 FOURTH AVENUE • NEW YORK 10, N. Y.

World's largest distributors of X-Ray Films and X-Ray Accessories.

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☐ Please send your bulletin on Picker Flexible Film Holders.

☐ Please arrange for demonstration of Picker Flexible Film Holders at our Plant.

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Schiller, Clarence E. (D), 503 Crestview St., Jeffersonville, Ind.
Schlatter, Henry J. (D), 1941 Payne St., Louisville, Ky.
Skuters, Roy (C), 2710 Montana, Louisville, Ky.
Thomas, James Bernard (C), 1233 S. 10th St., Louisville, Ky.
Veling, Michael J. (D), 2532 W. Market St., Louisville, Ky.
Wade, Lee S. (B), 652 Cane Run St., Harrodsburg, Ky.
Wallace, H. C. (C), 6075 Newart Rd., Louisville, Ky.
Wells, Lawrence S. (D), P. O. Box 27, Shively, Ky.
White, E. L. (A), 2601 Third St., Louisville, Ky.
Williams, James Henry (D), 1538 Rear 10th St., Louisville, Ky.

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Gallagher, Frank Howard (C), 3355 N. 57th St., Milwaukee, Wis.
Olsen, Lewis B. (C), 1030 E. Fairmount Ave., Whitefish Bay, Wis.

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Baxley, John J. (B), 66—5th Ave., Prichard, Ala.
Harris, W. H., Sr. (B), 202 Michigan Ave., Mobile, Ala.
Sherry, George H. (B), 453 Church St., Mobile, Ala.

NEW YORK

Beckerman, Milton B. (D), 228 Manor Place, Greenport, L. I., N. Y.
Brigham, Theodore W., Jr. (A), 306 Manor Place, Greenport, L. I., N. Y.
Cordovi, Marcel A. (C), 111-10—76 Rd., Forest Hills, N. Y.
Giles, Herbert (C), 70-01—113th St., Forest Hills, N. Y.
Goho, Lawrence O. (C), 66 Mackay Pl., Brooklyn, N. Y.
Hyman, Archie L. (D), 7 Wainwright St., Rye, N. Y.
Kelly, James P. (D), Federal Shipbldg. Co., 109 Orient Ave., Jersey City, N. J.
Martinez, Celso (D), 259 Bergen St., Brooklyn, N. Y.
Montiglio, Nino (B), 16 Green St., Huntington, L. I., N. Y.
Reiter, Fred W. (D), 326—6th St., Greenport, L. I., N. Y.
Schoen, Oscar (C), P. O. Box 267, Farmingdale, N. Y.
Smith, Frederick Thomas (D), Box 438, Greenport, L. I., N. Y.
Stevens, Theodore (D), Box 408, Greenport, L. I., N. Y.
Wilde, James R. (B), 57 Harvard St., Williston Park, L. I., N. Y.
Zeis, George W. (C), Specialty Products & Engr. Corp., 230 Park Ave., New York, N. Y.

NEW JERSEY

Collins, John C. (C), Boys Vocational School, 41 N. Illinois Ave., Atlantic City, N. J.
Riley, John (B), 614 N. Clinton St., Trenton, N. J.
Schimalog, Anthony (C), 16 Enterprise Ave., Trenton, N. J.

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Bohlke, Hailey W. (D), 70 Academy St., Amsterdam, N. Y.
Masi, Edward (D), Box 32, St. Johnsville, N. Y.
Torelli, Dominick J. (D), 1007 Strong St., Schenectady, N. Y.
Torelli, John A. (D), 1703 Van Vrarkin Ave., Schenectady, N. Y.

NORTHWEST

Hackett, Thomas F. (B), 1110 E. Superior St., Duluth, Minn.
Hohl, James (C), Stremel Bros. Mfg. Co. 260 Plymouth Ave., N., Minneapolis 11, Minn.
Lee, Edmund (C), 408 N. Wheeler Ave., St Paul, Minn.
Remmele, Fred L. (C), 1097 Ottawa Ave., West St. Paul, Minn.
Scott, Frank W. (B), 17—2nd St., S. E., Minneapolis, Minn.

OKLAHOMA CITY

Hopkins, W. W. (D), 2340 N. W. 19th St., Oklahoma City, Okla.

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Kelly, N. J. (D), 620 W. Lake, Peoria, 4, Ill.
Maddox, Emett S. (D), 601 W. Reservoir Blvd., Peoria, 4, Ill.

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Read, J. H. (C), Ergolyte Mfg. Co., 3627 N. Lawrence St., Philadelphia 40, Pa.

PITTSBURGH

Armstrong, H. C. (C), 901 Pennsylvania Ave., Pittsburgh 12, Pa.
Craig, G. M. (C), Carnegie-Illinois Steel Corp., 545 Central Ave., Johnstown, Pa.
McClaus, Thomas (C), 534—3rd St., Pitcairn, Pa.
Morgan, T. W. (C), American Rolling Mill Co., Butler, Pa.
Ruedebusch, John William (C), Westinghouse Elec. & Mfg. Co., Trades Training Dept., 3N-22, East Pittsburgh, Pa.
Wilder, Arthur B. (C), Porcelain Metal Products Co., Rosslyn Rd., Carnegie, Pa.

PUGET SOUND

Berry, Floyd H. (B), 3809 N. 9th St., Tacoma, Wash.
Tepley, George L. (B), Webster Welding Co., 1211 Pine St., Seattle, Wash.

ST. LOUIS

Crowley, Anthony W. (B), McNamar Boiler & Tank Co., Box 210, Salem, Ill.

SAN FRANCISCO

Atkinson, A. E. (B), American Chain & Cable Co., 695 Bryant St., San Francisco, Calif.
Clinkscale, Roy W. (B), Mare Island Navy Yard, Shop Supt. Office, Mare Island, Calif.
Day, Donald W. (C), 30 Northgate Dr., San Francisco, Calif.
French, Robert F. (B), 1711 N. Commerce St., Stockton, Calif.
Haines, Frank B. (C), 709 Ensenada Ave., Berkeley, Calif.
Ovregaard, Olav (B), Moore Dry Dock Co., Ft. of Adeline St., Oakland, Calif.
Patton, Fred T. (B), 300 Yale Ave., Berkeley 8, Calif.
Skugrud, Vernon A. (C), 2928 Barrett St., Oakland, Calif.
Stark, Theodore N. (C), 1776 Tulare Ave., Richmond, Calif.

TOLEDO

Dunbar, Paul L. (D), 1508—22nd St., Toledo, Ohio.
Spevak, Leon M. (B), 701 Tecumseh, Toledo, Ohio.

WASHINGTON, D. C.

Herrick, Clayton B. (B), Welding Casting & Forging, Section 692, Bureau of Ships, Navy Dept., Washington, D. C.

WESTERN NEW YORK

Kirkpatrick, Lt. Comdr. Edward W. (B), U. S. C. G. R., 139 Highgate Ave., Buffalo, N. Y.

WICHITA

Barrett, M. A. (A), Beech Aircraft Corp., Wichita, 1, Kan.
Bukner, Belton D. (B), 139 S. Sedgwick St., Wichita, Kan.
Carnahan, G. R. (A), Aircraft Welders, Inc., 403 Beacon Bldg., Wichita, Kan.
Clark, Duane L. (B), 2107 S. Water, Wichita, Kan.
Coonfield, Roy A. (C), 402 N. Volutsia, Wichita, Kan.
Coppenbarger, O. C. (B), 1957 S. St. Francis, Wichita, Kan.
Dawson, John W. (B), 111 S. Bleckley Dr., Wichita, Kan.
Dudley, Charles R. (B), 4859 Salina, Wichita, Kan.
Fossett, W. K. (B), Beech Aircraft Corp., Wichita, Kan.
Foster, J. B. (B), 4437 Boston Drive, Wichita, Kan.
Glassburner, Ray (B), 429 Mathewson Court, Wichita, Kan.
Gore, Theron E. (B), 902 S. Wichita St., Wichita, Kan.
Green, Carl R. (B), Beech Aircraft Corp., 6500 E. Central, Wichita 1, Kan.
Hammer, Earl A. (B), 237 N. Holyoke, Wichita, Kan.
Haselwood, Howard N. (B), 263 E. Douglas Eastborough, Wichita 15, Kan.
Hege, K. E. (B), 3103 Maplewood Drive, Wichita, Kan.
Hetrick, Glenn (B), 522 S. Holyoke, Wichita, Kan.
Hunt, A. T. (B), 603 N. Fountain, Apt. B, Wichita, Kan.
Kirkwood, W. E. (B), 222 N. Athenian, Wichita, Kan.
Lampton, M. L. (C), Air Reduction Sales Co., 402 E. 29th St., Wichita, Kan.
Lippitt, Arthur H. (B), 546 Marcilene Tr., Wichita, Kan.
McCurry, R. G. (B), 1816 Ida, Wichita, Kan.
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King, John A. (D), Reedsville, Pa.
Knote, Harry E. (D), Milroy, Pa.
Knupp, Wilbert (C), 3029 Chestnut St., Camp Hill, Pa.
Nale, Glen H. (D), R. D. 3, Lewistown, Pa.
Nale, L. (D), Thompsontown, Pa.
Naylor, C. Craig (C), P. O. Box 82, Harrisburg, Pa.
Partchey, Roy H. (D), R. 2, Lewistown, Pa.
Zook, Marlin R. (D), Belleville, Pa.

YOUNGSTOWN

Oehler, Irving A. (B), American Welding & Mfg. Co., Warren, Ohio.

NOT IN SECTIONS

Clark, Sidney Warren (B), Aetna Steel Const. Co., P. O. Box 3386, Jacksonville, Fla.
Clark, Willis M., A.A.F., 1C (B), Stinson Aircraft Div. Vultee, Inc., Dept. 27, 12-16, Campau St., S. W., Grand Rapids, Mich.
Fournier, Murrell A. (B), Bechtel, Price & Callahan, Skagway, Alaska.
Hammond, Henry N. (C), 58 Mill St., Brightlingsra, Colchester, Essex, England.
Horejs, W. A. (B), P. O. Box 2343, West Palm Beach, Fla.
Hudson, Charles R. (B), 7335 N. McKenna Ave., Portland 3, Ore.
Kelly, Lawrence Lees (D), The Linde Air Products Co., 48 W. McLemore Ave., Memphis, Tenn.
McCoy, Alton A. (B), 3107 N. E. 40th Ave., Portland, Ore.
Murray, John S. (B), 29 Hathaway Drive, Giffnock, Glasgow, Scotland.
Ogden, John Orford (B), Welded Products Pty. Ltd., 94 O'Riordan St., Alexandria, N. S. W., Australia.
Watt, W. W. (B), British Oxygen Co., Grosvenor House, Parklane, London, 4-1, England.

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CINCINNATI

Hock, Alvin, Jr. (from D to C), 1566 Hollywood Ave., College Hill, Cincinnati, Ohio.

LOS ANGELES

Ganahl, Lawrence E. (from D to C) 230 So. Beechwood Dr., Burbank, Calif.
Perrin, Max (from D to C), 2614 Olive St., Huntington Park, Calif.

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Zeuthen, Albert W. (from F to C), 230—75th St., Brooklyn, N. Y.

NORTHERN NEW JERSEY

Jasmine, Joseph J. (from D to C), 209 Union St., Lodi, N. J.
Koch, Harry (from D to C), 910—16th St., Union City, N. J.
Plaskon, John (from D to C), 56 East 5th St., Bayonne, N. J.

SAN FRANCISCO

Beidler, J. W. (from C to B), 415 Stannage St., Albany, Calif.

WASHINGTON, D. C.

Argabright, J. A. (from D to C), 34 Langley Ave., Beacondale, Newport News, Va.

NOT IN SECTIONS

Hamilton, Harold (from D to C), R.F.D. 6, Berneway Dr., Ft. Wayne, Ind.
Walters, Lester O., Cpl. (from D to C), Sinclairville, N. Y.

During Month of August

CHICAGO

Matis, Henry A. (from C to B), Pullman Standard Car Mfg. Co., 11001 Cottage Grove Ave., Chicago, Ill.
Menzies, J. C. (from C to B), C. E. Phillips & Co., 332 S. Jefferson St., Chicago, Ill.
Smith, Lloyd M. (from C to B), Utilities Engrg. Inst., 1314 Belden Ave., Chicago, Ill.

CLEVELAND

Allison, Edwin F. (from C to B), 3656 Latimore Rd., Shaker Heights, Ohio.
DeWitt, Carl J. (from C to B), Olmsted Falls, Ohio.

DETROIT

Feldman, Bill (from C to B), 12192 Shore Acres, Fenton, Mich.

LOS ANGELES

Gowing, J. C. (from C to B), 1007 Santa Fe Ave., Los Angeles, Calif.
Hill, Herbert W. (from D to C), 214 McNees Ave., Whittier, Calif.
Karnes, N. J. (from C to B), 4949 Weik Ave., Bell, Calif.
Shook, Martin (from D to C), 4541 Grand Ave., R.F.D. 1, La Canada, Calif.

LOUISVILLE

Allen, Frank (from D to C), 1025 Rodgers St., Louisville, Ky.

NEW YORK

Greenberg, Simon A. (from C to B), 2137 E. 23rd St., Brooklyn, N. Y.
Leib, Otto S. (from D to C), 1360 Ogden Ave., Bronx, N. Y.

NEW JERSEY

Andrews, F. H. (from C to B), Andrew's Welding Service Co., 28 Ogden St., Newark, N. J.
Hagey, Eugene (from D to C), 443—16th Ave., Irvington, N. J.

NORTHERN NEW YORK

Lipschitz, William L. (from C to B), 458 South St., Pittsfield, Mass.

NORTHWEST

Mayor, William P. (from C to B), Farwell Metal Fab. Div., E. Kellogg Blvd. & Jackson St., St. Paul, Minn.
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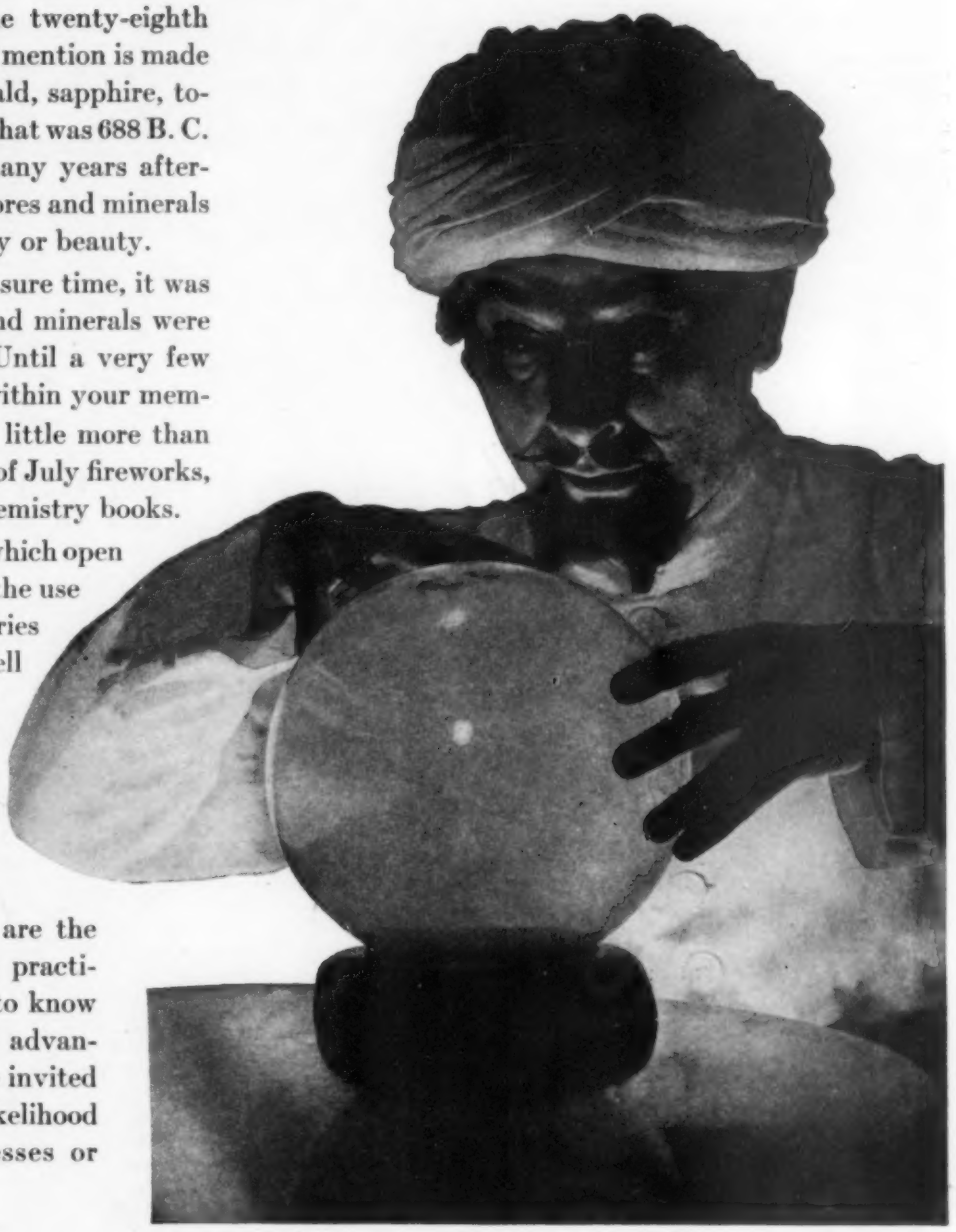

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Scharnberg, H. S. (from D to C), 415—69th St., Houston, Tex.

TOLEDO

Metz, Virgil P. (from D to C), North Gate Manor, Locust & Erie Sts., Toledo, Ohio.

Vickery, J. F. (from C to B), General Elec. Co., 1102 W. Central, Toledo, Ohio.

WICHITA

Newkirk, R. M. (from C to B), 1553 N. Poplar, Wichita, Kan.

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SECTION ACTIVITIES

CLEVELAND

The first meeting of the Cleveland Section for the coming season is scheduled for October 13th. As usual the meetings will be held at the Cleveland Engineering Society, 2136 E. 19th St.

The program of speakers for technical sessions for the coming year is practically completed. A special effort has been made to select appropriate speakers and subjects, which will provide a thoroughly instructive series of meetings. The speakers for the Coffee Talks have been selected on the basis of entertainment as well as information on topics of current interest.

Arrangements are in process at the present time with Case School of Applied Science for a course in metallurgy. The Section is also planning to hold another War Production Conference some time during the year.

The present Cleveland Section officers are as follows: R. J. Kriz, Chairman; Ross Yarrow, Vice-Chairman; A. Leslie Pfeil, Secretary and Treasurer.

COLUMBUS

The following are the newly appointed officers and committeemen of the Columbus Section: *Chairman*, J. L. Purdy, Buckeye Steel Casting Co.; *Vice-Chairman and Program Director*, F. W. Shackelton, Central Ohio Welding Co.; *Secretary-Treasurer*, Geo. S. Herren, Seagraves Corp.; *Membership Committee Chairman*, Gene Beeler, Arc Welding Co.; *Attendance Committee Chairman*, Clay W. Roberts, Pennsylvania R. R.; and *Publicity Committee Chairman*, F. B. Dahle, Battelle Memorial Institute.

DETROIT

The 1943–44 Season opened on September 3rd with J. H. Humberstone, District Vice-Chairman, discussing the functions of the National Headquarters Executive Staff, while Dr. Harry C. Boardman of the Chicago Bridge & Iron Co. very ably presented the subject of "Locked-Up Stresses in Steel Structures."

The Flint meeting was held on September 2nd at the Capitol Hotel and the Detroit meeting on September 3rd at the Horace H. Rackham Memorial Building.

LEHIGH VALLEY

The Lehigh Valley Section held its first Technical Meeting on October 4th. The Section is being launched with a membership of over a hundred. Considerable increase in membership is expected when the Section gets under way.

The officers for this Section for 1943–44 are: *Chairman*, H. W. Lawson, Bethlehem Steel Co.; *Vice-Chairman*, J. W. Kenworthy, Mack Motors; *Secretary-Treasurer*, Julius Naab, Ingersoll Rand Co.; and *Board of Directors:* G. E. Doan, C. W. Reid, F. R. Fairhurst, C. L. Kreidler, L. D. Draper and P. H. Barron.

Schedule of meetings to be held at 8 P.M. at the Hotel Bethlehem in Bethlehem, Pa., dinner at 6:30, are as follows:

October 4, 1943—"Distortion Problems," by C. H. Jennings, Westinghouse Elec. & Mfg. Co.

November 1, 1943—"Welding in Aircraft Production," by P. H. Merriman, Glenn L. Martin Co.

December 6, 1943—"Fabrication of Ships and Buildings," by LaMotte Grover, Air Reduction Sales Co.

February 7, 1944—"Design of Electrode Coatings," by Dr. J. W. Miller, Reid-Avery Co.

March 6, 1944—"Structural Steel Fabrication by Resistance Welding," by R. T. Gillette, General Electric Co.

April 3 and May 1, 1944—To be announced later.

NEW YORK

The first regular monthly technical meeting of the New York Section was held on Tuesday, September 14th, at the Engineering Societies Building. The subject for the evening was "Aircraft Welding." Technical Chairman was H. O. Klinke, welding engineer, Republic Aviation Company, Farmingdale, N. Y.

The speaker for the evening was P. H. Merriman, welding engineer, the Glenn L. Martin Company, Baltimore, Md., who spoke on the subject "Rigid Engineering Control in Aircraft Welding." Mr. Merriman described the spot welding of aircraft structures, emphasizing the necessity for rigid engineering control in order to realize the full potentialities of the processes. His talk, which covered the subject completely from the design of the part to the inspection of the finished article, was well illustrated with numerous lantern slides. Following his talk, Mr. Merriman presented an extremely interesting United States Navy training film on the various welding processes used in aircraft construction.

The new General Electric film, "The Inside of Atomic-Hydrogen Arc Welding," was shown by E. Vom Steeg, welding specialist for G. E. This training film, in full color and sound, showed the fundamentals on regulation of welding current and hydrogen supplies, as well as complete instructions for procedure technique.

The evening opened with a half-hour question and answer period conducted by C. Kandel, Craftsweld Equipment Corp., New York.

PITTSBURGH

The following meetings have been scheduled for the coming season. All meetings will be held as usual in the Auditorium of the Mellon Institute of Industrial Research (Oakland) and a cordial invitation is extended to all members and interested parties to attend and participate.

Oct. 13, 1943—"Inspection of Welded Structures," by R. B. Lincoln, Director, National Weld Testing Bureau, a division of the Pittsburgh Testing Laboratory, Pittsburgh.

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Nov. 17, 1943—"Weldability of Steel," by A. B. Kinzel, Chief Metallurgist, Union Carbide & Carbon Research Labs., Inc., New York.

Jan. 19, 1944—"Welding in Shipbuilding," by LaMotte Grover, Welding Engineer, Air Reduction Sales Co., New York.

Feb. 16, 1944—"Metallurgy of Gas Welding," speaker to be announced.

March 15, 1944—"The Spotweldability of Low Carbon and Other Aircraft Steels," by Leon C. Bibber, Welding Engineer, Carnegie-Illinois Steel Corp., Pittsburgh.

April 24, 1944—Seventh Annual Tri-State Convention. Principal Speaker: Roy W. Emerson, Pittsburgh Piping & Equip. Co., Pittsburgh. Subject to be announced.

ST. LOUIS

The following are the subjects and speakers for meetings of the St. Louis Section 1943-44. Meetings will be held at the Engineers' Club, 4359 Lindell, on the second Friday of each month, with the exception of the March meeting which will be held on Thursday, March 2nd.

September 10, 1943—"Weldability of Steels," by L. S. Marsh, Manager, Dept. of Inspection and Metallurgy of Inland Steel Co., Chicago. Also colored movie on the manufacture of steel.

October 8, 1943—"Training of Welding Operators," by R. G. Hawley, Superintendent of Welding, Link-Belt Ordnance Co., Chicago.

November 12, 1943—"Formed Steel Tubing and Its Application to Welded Structural Design," by H. S. Card, Formed Steel Tube Institute, Cleveland.

December 10, 1943—"Aircraft Welding," by C. W. Steward, Head of Metal Fabrication Section, Research Lab., Airplane Div., Curtiss-Wright Corp., Buffalo, N. Y.

January 14, 1944—"Grinding Problems Pertaining to Welding," by H. W. Wagner, Research Labs., Mechanical Section, Norton Co., Worcester, Mass.

February 11, 1944—"Stainless Steel Welding" (Name of individual to be announced later), Allegheny-Ludlum Steel Corp., Brackenridge, Pa. New movie to be shown on subject of stainless steel welding.

March 2 (Thursday)—"Welded Buildings," by Albert S. Low, Vice-President and Chief Engineer, Austin Co., Cleveland. Joint meeting with Engineers Club.

April 14, 1944—"Automatic Welding," by J. Chyle, Research Welding Engineer, A. O. Smith Corp., Milwaukee, Wis.

May 12, 1944—"Hard Facing and Its Application to Industry," by J. Gallaher, Engineer, Haynes Stellite Co., Chicago.

June 9, 1944—"Executive and Superintendent's Night"—Annual dinner meeting. Speaker of national prominence to be announced.

SAN FRANCISCO

A talk on Welding Stress was given at the August 27th meeting of the San Francisco Section by S. H. Edwards, a Welding Engineer of renown, who has specialized in the study of Welding Stress for many years, and who now operates the Welding Eng. and Mfg. Co. in Richmond.

WESTERN NEW YORK

The following officers have been elected by the Western New York Section for the coming year: *Chairman*, Joseph Cousins, J. D. Cousins & Sons Boiler Works, Buffalo; *Vice-Chairman*, Stuart L. Rich, Kenmore, N. Y.; *Treasurer*, Robert Siemer, Allan Mfg. & Welding Co., Buffalo; and *Secretary*, Richard S. Lane, Ross Heater & Mfg. Co., Inc., Buffalo.

WICHITA

At a business meeting held on August 24th the following officers were elected for the coming year: *Chairman*, M. A. Barrett, Beach Aircraft Corp.; *Vice-Chairman*, R. L. Townsend, Tweco Products Co.; *Secretary*, Don Schwartz, Air Reduction Sales Co.; and *Treasurer*, E. A. Bussard, Coleman Lamp & Stove Co.

The following committee chairmen were also appointed: *Program*, E. A. Bussard and *Publicity*, Art Lippitt.

WASHINGTON, D. C.

Newly elected officers for the fiscal year are: *Chairman*, H. L. Ingram; *Vice-Chairman*, W. B. Bunn; *Treasurer*, Robert F. Wood; and *Secretary*, B. J. Brugge.

Executive Committee (two years): L. H. Fawcett, W. H. McKenzie, A. W. Lubers, G. E. Knox and R. S. Stover.

Executive Committee (one year): A. G. Bissell, A. Amirikian, C. E. Jackson, R. B. Swope, S. W. Tranier and J. C. Ritter.

Membership Committee, Chairman, J. C. Ritter.

YORK-CENTRAL PA.

Lt. Commander O. R. Sutherland of the U. S. Navy Yard, Philadelphia spoke on "Specifications—Their Theory, Preparation and Use, and the Control of Required Inspection Thereunder," at the September 8th meeting of the York-Central Pennsylvania Section.

Employment Service Bulletin

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Industrial electronics equipments are playing an indispensable role today in America's record-breaking war production. A comparative newcomer to industrial plants since the major developments in industrial electronics have taken place since World War I, this industrial tool has been directly responsible for saving millions of man- and machine-hours, and millions of pounds of critical materials since Pearl Harbor, according to General Electric officials speaking at a Conference on Industrial Electronics, September 14th. The conference was held at Schenectady, N. Y.—the birthplace and proving grounds for a great many significant developments in the science of electronics.

At the conference, which reviewed what electronics has done, is doing, and can do in industry, it was pointed out that General Electric, for example, now has hundreds of electronics equipments available to industry to help do jobs better and to take over jobs that could not be done otherwise. Welding, heat-treating, positioning, speed matching, current and voltage control, temperature control, color matching, motor control, inspection and counting, process control, measurements and testing, power rectification and frequency changing, industrial X-rays, precipitation, and decorative lighting are some of the fields falling within the scope of this equipment.

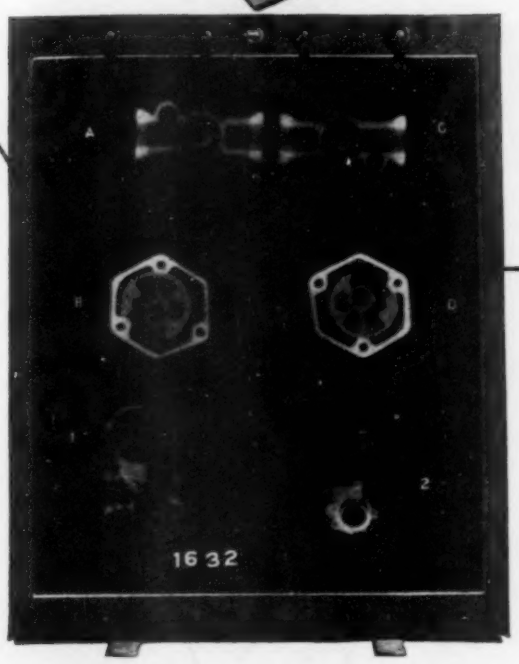
E. H. Alexander stated that no single industrial electronic equipment has contributed more to war production than resistance welding control. Precision timing and heat control have made it possible to fabricate many new and special metal alloys.

An important recent contribution to the art of resistance welding control is the electronic current-regulating compensator. The current regulator compensates for variations in line voltage and for the amount of magnetic material in the throat of the welding machine, thus making it possible to obtain consistent welds in welding parts of irregular and varying shapes.

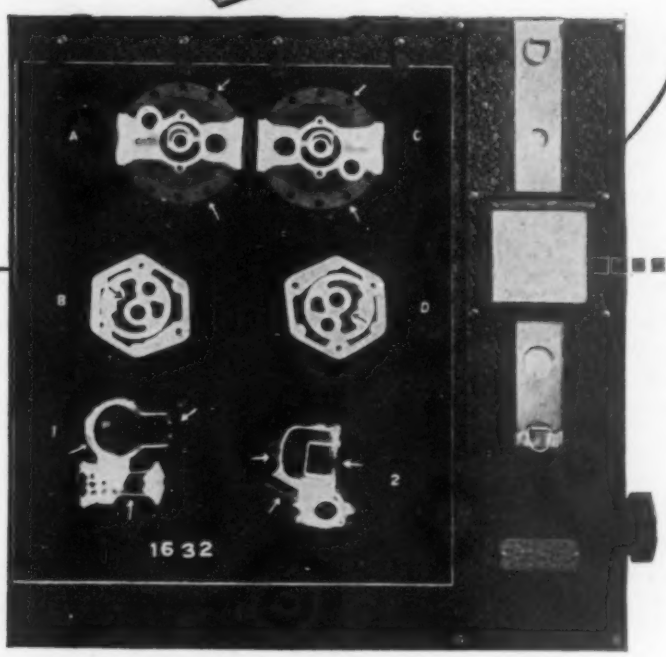
The increased use of aluminum alloys, especially in heavy gages, has brought forward the energy storage method of resistance welding to supply the very high currents required by these materials. In this system, an electronic rectifier takes power from a-c lines and converts it to direct current which is stored, usually in capacitors. The voltage stability of the power supply is thus greatly increased since the current demand is reduced and the load divided over three phases.

DOES YOUR X-RAY INSPECTION SHOW

THIS? or THIS?



VITAL DETAIL MISSED WITH ORDINARY ILLUMINATION



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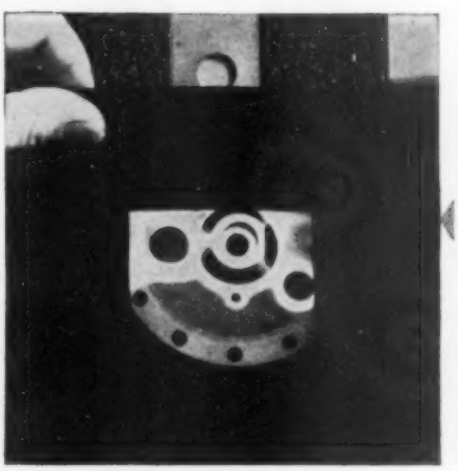
HERE are two views of the *same* X-ray film. The *only* difference is in the illuminators—an ordinary illuminator in one instance, a KELEKET High Intensity Illuminator in the other.

But what an improvement the KELEKET illuminator makes in the accuracy and fidelity of your X-ray inspection! Now no flaw can escape notice—with every inch of a 14" by 17" film brilliantly lighted! And for extra-close inspection of critical areas, a 3-inch spot gives four times the illumination of the large front surface.

Ordinary illumination may be adequate for films of 1.5 density or less, but the KELEKET High Intensity Illuminator makes it possible to use film of up to 4.0 density and beyond, with a marked improvement in radiographic contrast.

And for viewing film of varying densities, a stepless voltage control supplies optimum illumination for each density. For full information on the KELEKET High Intensity Illuminator, write for Catalog F-11 today.



For inspecting critical areas, this 3" spot gives four times the illumination of the large surface.

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PIONEER CREATORS OF *QUALITY* X-RAY EQUIPMENT SINCE 1900

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SECRETARY—J. V. TURNER, Air Reduction Sales Co., 336 Spring St., N. W., Atlanta, Ga.

BIRMINGHAM — 3rd Fri.
CHAIRMAN—C. C. PINCKNEY, Birmingham Boiler & Eng. Co., 41st St. & 8th Ave., North, Birmingham, Ala.
SECRETARY-TREASURER—W. L. POOLE, Air Reduction Sales Co., 2825 N. 29th Ave., Birmingham, Ala.

BOSTON — 2nd Mon.
CHAIRMAN—F. W. DAVIS, E. B. Badger & Sons Co., 75 Pitts St., Boston, Mass.
SECRETARY—P. N. RUGG, 22 Eastern Ave., Wakefield, Mass.

CANAL ZONE — 1st Tues.
CHAIRMAN—CLIFFORD B. JONES, Box 533, Diablo Heights, Canal Zone
SECRETARY—R. E. HOLLICK, Box 924, Diablo Heights, Canal Zone

CHATTANOOGA, TENN. — 1st Wed.
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SECRETARY-TREAS.—R. G. WILSON, National Cylinder Gas Co., 1410 Cowart St., Chattanooga, Tenn.

CHICAGO — 3rd Fri.
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SECRETARY—ERNEST F. CAHN, Ohio Valley Sales Co., 3018 Robertson Ave., Cincinnati, Ohio

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SECRETARY—G. S. HERREN, The Seagrave Corp., Columbus, Ohio

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SECRETARY—J. IMPERATI, American Brass Co., Ansonia, Conn.

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SECRETARY—G. N. SIEGER, S-M-S Corp., 1165 Harper Ave., Detroit, Mich.

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SECRETARY—GEO. MANN, J. D. Adams Co., Indianapolis, Ind.

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SECRETARY—JAMES B. DAVIS, Tulsa Testing Labs., Tulsa, Okla

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